AERONAUTICAL ENGINEERING REVIEW

INSTITUTE OF THE AERONAUTICAL SCIENCES

JULY 1950

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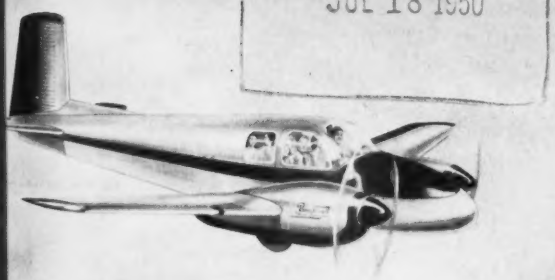

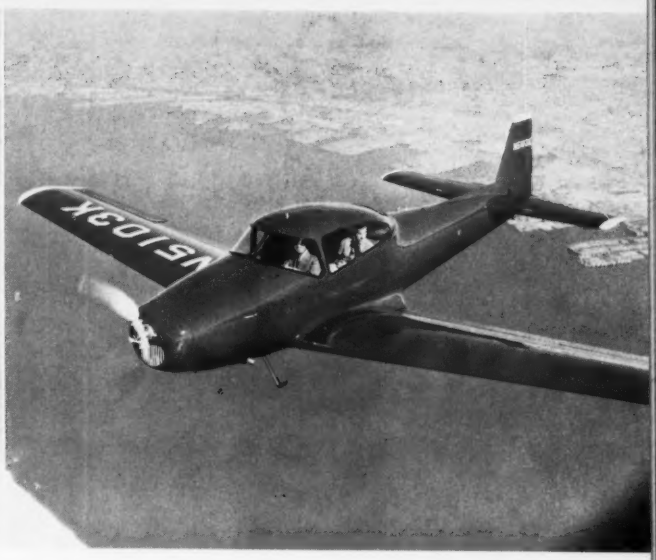

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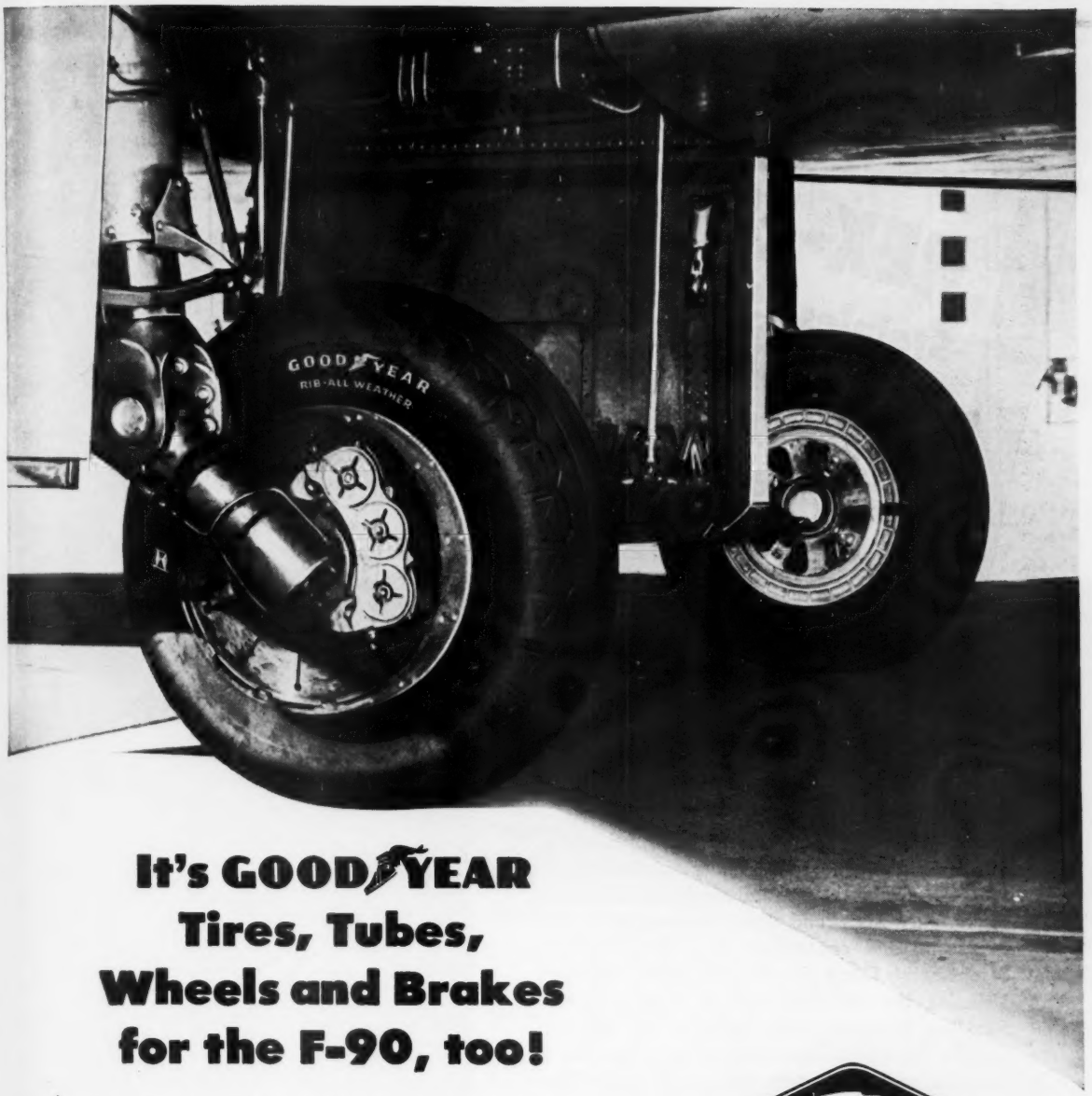

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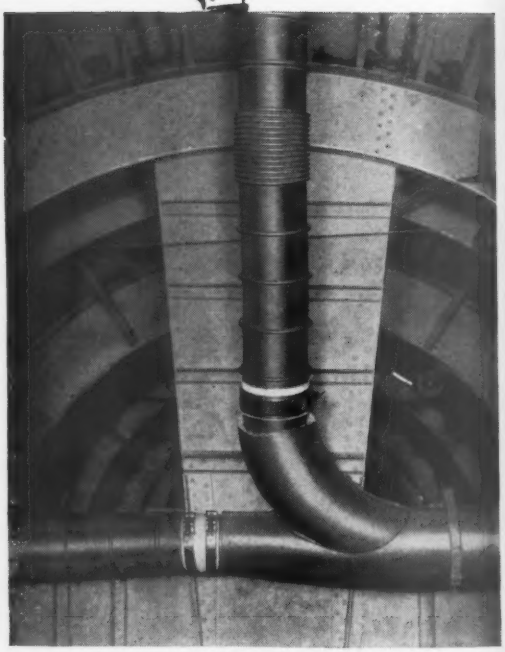

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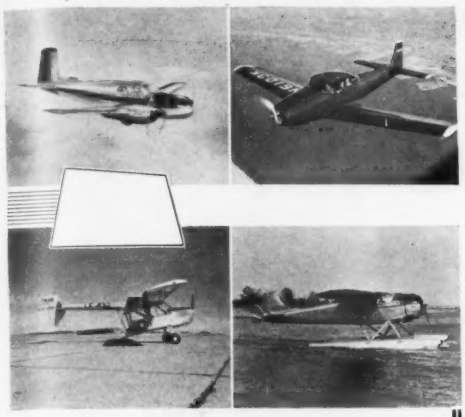

Cover—Personal Aircraft Meeting Issue. *Top left,* Beechcraft Twin Bonanza; *top right,* Ryan Navion; *bottom left,* Boeing L-15; *bottom right,* Cessna 190.

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AERONAUTICAL ENGINEERING REVIEW

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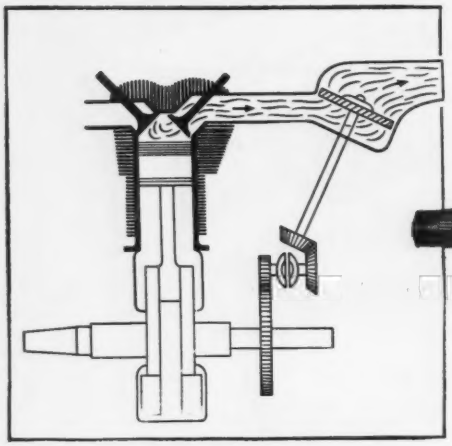

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I. A. S. News

A Record of People and Events of Interest to Institute Members

First Year's Operation of Los Angeles Building

Over 12,000 Engineers and Scientists Used I.A.S. Western Headquarters Building in Past Year; Building Houses Aircraft Industries Association of America, Western Coordination Office of the N.A.C.A., Pacific Aeronautical Library, and I.A.S. Western Headquarters Offices.

"I'LL MEET YOU at the Institute." Several thousand Los Angeles engineers and scientists have used those words since the I.A.S. Western Headquarters was completed a year ago. The building has become a landmark around which the activities of nearly all of the technical societies in Los Angeles revolve. This is appropriate because all of the sciences contribute to aeronautics. Through its doors in the first year have passed more than 12,000 engineers and scientists, members of 25 different societies, in their pursuit of professional improvement.

"I'll meet you at the Institute"—12,000 strong—means that a $500,000 tool made possible principally by local companies is fulfilling its objective of advancing the sciences of aeronautics.

Here we find gatherings several nights weekly of experts in chemistry, metallurgy, mechanics, physics, acoustics, heat transfer and fluid mechanics, electronics and mathematics—all of the sciences whose broad progress supports many aeronautical applications.

These meetings of technical professionals from outside the aircraft industry make a fitting background for the general and special meetings of the Institute itself. They symbolize the place of the Institute as the catalyst and coordinating agency for all sciences in their specific application to aeronautics.

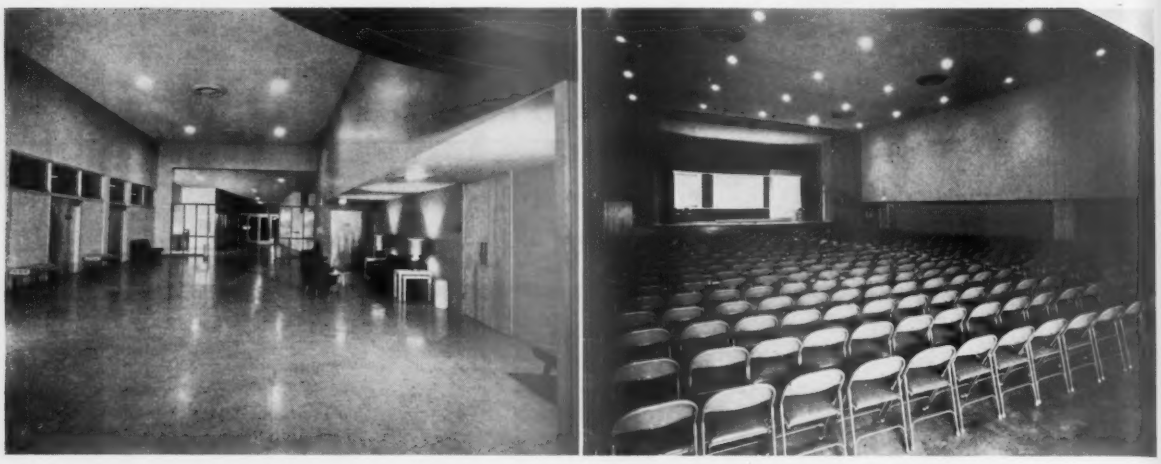
Further crystallizing this special role, the Los Angeles Section has held joint meetings with the Aeromedical Association, the Instrument Division of A.S.M.E., the Metallurgical Branch of the A.I.M.E. and, along with five other engineering societies, sponsored a 2-day Heat Transfer and Fluid Mechanics Institute in the I.A.S. building in June.

Availability of the building—with its spacious, fully equipped auditorium, its lecture room, and its dining, lounge, and library facilities—has, of course, sharply accelerated local I.A.S. activity. The number of Section meetings, under the chairmanship of Philip A. Colman, has doubled, bringing to the front a new tool of technical progress in the form of Specialist Meetings.

These Specialist Meetings, carried on in addition to the customary monthly general interest sessions, bring together top experts in relatively narrow fields of interest under informal conditions where the experts freely discuss, in their own jargon and equations, the latest common problem or development in their specialty.

In the spring of 1950, outstandingly successful seminars or forums of this type were staged in the fields of stress-strain-time relations, power control sys-

I.A.S. Los Angeles Staff. ***Front row, left to right:*** **Carol Cunningham, Cataloger; Barbara Tockerman, Helen Kulp, and Barbara Harris, Library Clerks.** ***Second row, left to right:*** **Artrice Carter, Building Custodian; John Woodard, Lounge Lessee; Irene Gorsky, Secretary; Nell S. Steinmetz, Librarian; James L. Straight, Assistant Director; Thomas Malta, Lounge Lessee.**



I.A.S. Western Headquarters Building interior shots. *Left:* Foyer. *Right:* Auditorium.

tems, and supersonic boundary-layer control.

Each such forum fosters a demand for a subsequent get-together on some point raised in the discussion. For example, the structures session noted above created a demand for a panel of physicists and metallurgists to elucidate the chain of events in molecular behavior that is involved in stress and strain when the factor of time is added. The forum concluded that theory regarding strain-time relations is about at the point where aerodynamicists found themselves before they learned about boundary-layer turbulence. They decided that aggressive discussion among top experts should continue in order to delineate further the directions in which intensive experiment is needed, with great rewards at stake.

This invariable reaction—this striking stimulation of group interest—foreshadows eventual scheduling of two or three Specialist Meetings monthly, to serve groups of from 20 to 200 regularly in the narrowest specialties. No textbook yet carries the information sought in these discussions. Every argument carries the excitement of pioneering, with several leaders keeping the discussion in focus but still uninhibited.

Meanwhile, entirely separate meetings were inaugurated this spring by the newly organized Historical Branch of the Los Angeles Section, under Chairmanship of John Sloan. Independent programs of speakers, movies, and slides are carried out by the Branch. On one week-end, the auditorium and foyer were filled with a special exhibit of aeronautical photographs and models. On another occasion, a temporary television setup permitted the Branch to witness a TV program of aeronautical history content.

The Branch maintains its own fully equipped darkroom and negative files, circulating prints and enlargements on a cost basis and is already receiving donations of interesting—perhaps priceless—photos from private keepsake files.

Use of the building for social activities began with highly successful dances given by the Douglas Santa Monica engineering department, the North American Field Service department, and the Institute Section, which inaugurated an annual "Test Hop." The second year appears to be sure of being crowded for many Saturday night aviation dances.

Tenants in the Institute building from the beginning were the Aircraft Industries Association of America, in charge of Capt. Leland D. Webb, M.I.A.S., as Vice-President for the western region; and the Western Coordination Office of the National Advisory Committee for Aeronautics, under E. P. Hartman, M.I.A.S. The building also houses the Pacific Aeronautical Library of the I.A.S., with a staff of five, and the Institute's Western Headquarters Offices, in charge of James L. Straight, Assistant Director.

To this appropriate family of tenants, the Institute building is now regarded as a permanent home in which all have a personal interest and in which all participate. It centralizes the meeting activities of the three agencies and implements a logical, effective cooperation among them. N.A.C.A. and A.I.A. technical personnel are virtually all leaders in the I.A.S., and the companies interested in the three organizations are, of course, identical.

Committee meetings in the many departments in which the Aircraft Industries Association is now active

A portion of the Pacific Aeronautical Library, I.A.S. Western Headquarters Building.

especially in the technical fields, occupy the Lecture Room on most week days, sometimes involving as many as a dozen daytime conclaves in a single week. On a few occasions, such as the 2-day April conference on aviation noise abatement, A.I.A. makes free use of the large auditorium. Top Government and military aviation groups have learned that the Institute makes a perfect place for their western conferences, with desirable privacy.

Facilities of the Pacific Aeronautical Library are, of course, available to all three organizations in connection with their technical activities and reference needs.

In charge of scheduling all meeting activity in the building, including employment and supervision of caterers, is Miss Irene Gorsky, formerly a member of the Institute's New York staff. When not so occupied, she serves also as secretary to the Assistant Director. It is she who tallied up the 12,000 total attendance and just about knows them all personally.

University of Alabama Student Branch Organizes First Annual Southeastern Regional Meeting of I.A.S. Student Branches

Student affairs received a boost recently when the University of Alabama I.A.S. Student Branch was host, on April 21 and 22, to a Southeastern Regional Meeting, attended by representatives of six schools. About 80 persons were registered, including faculty and students from Alabama Polytechnic Institute, Georgia Institute of Technology, Mississippi State College, Louisiana State University, and the Universities of Alabama and Florida. Also present were visitors from the C.A.A. and the Alabama Department of Aeronautics. Honorary Chairman of the I.A.S. Student Branch at the University of Alabama is John W. Hoover, M.I.A.S., Associate Professor of Aeronautical Engineering.

Alabama's Student Branch Chairman John L. Burch presided at the afternoon session in Graves Hall. After a brief welcome, he introduced the first speaker, Prof. C. R. Pearson, University of Florida, who presented a timely, down-to-earth paper on what the aeronautical engineering graduate should expect and how he should act when he goes to work in the aircraft industry.

Alabama Polytechnic Institute's Bill DeWees followed with a student paper on "Boundary-Layer Control by Suction." He reviewed the elementary principles of boundary-layer control, using slides of typical streamline patterns to show effects of suction and blowing through spanwise slots. A comparison of performance of aircraft with and without boundary-layer control illustrated the gains to be expected from such applications.

Professor Alan Pope, M.I.A.S., Daniel Guggenheim School of Aeronautics, Georgia Institute of Technology, author of the well-known text, *Wind Tunnel Testing*, gave an interesting lecture on "Some Foreign Wind-Tunnel Design Features." He discussed some of the outstanding tunnels found in Germany and Japan when occupation forces took over. Of particular interest was the partially completed 100,000-hp. German tunnel, which was to have had a 26-ft. working section. Japanese tunnels were notable principally for their poor design features. Photographs and diagrams on slides illustrated Professor Pope's talk.

Alabama University's contribution was a student paper by Raymond A. Deep. He presented "A Method for Calculating the Performance of an Annular Jet Ejector." The ejector, a possible means of producing flow for some types of wind tunnels, was illustrated, and a formula was derived for calculating the induced or secondary flow in a typical configuration. Comparisons between calculated and experimental secondary weight flows illustrate the suitability of the semi-empirical expression, maximum error being roughly 10 per cent. Extension of curves by new test data would reduce this error.

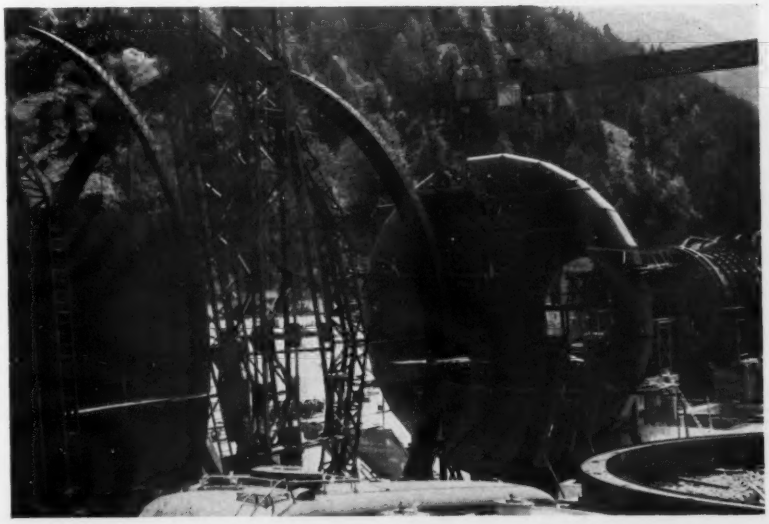
The afternoon session was adjourned with a visit to Hardaway Hall, where visitors were shown the aeronautical engineering laboratory, including a recently completed water table for demonstration of flow patterns, using aluminum powder suspended in water. From Hardaway Hall the group was led on a brief tour around the campus, ending with assignment of rooms at Northington Campus.

Eighty persons attended the dinner at the Burchfield Hotel. Visitors were introduced, including Asa Rountree, Jr., Alabama's State Director of Aeronautics, and C.A.A. engineers Larry C. Sentker, T.M.I.A.S., Washington, and Will H. Trammell, Atlanta. Professor John W. Hoover, M.I.A.S., of Alabama, conveyed greetings from the parent Institute at New York. After-dinner entertainment by Jack Andrews, local comedian, consisted of a humorous monologue and a ventriloquism act, which were much enjoyed.

At the evening session, Prof. F. R. Steinbacher, A.F.I.A.S., Head of the University of Alabama's Department of Aeronautical Engineering, introduced the guest speakers. Dr. August Raspet, M.I.A.S., Engineering Research Station, Mississippi State College, presented a paper on "Motorless Flight Research." He discussed the use of sailplanes as meteorological instruments and as aids to study of bird flight. Aerodynamics of soaring flight was discussed. Desirable features of sailplanes were mentioned, with statements on methods tried by the speaker. The safety of sailplanes was emphasized. Problems of design of high-performance sailplanes involve use of latest developments in aerodynamics and structures.

(*Continued on page 9*)

Bell-mouth of captured German 8-m. 100,000-hp. wind tunnel at St. Otztal, near Innsbruck, Austria. Professor Alan Pope, Georgia Institute of Technology, discussed construction of this uncompleted tunnel in his paper "Some Foreign Wind-Tunnel Design Features."



Personal Aircraft Meeting Highlights

Seventh Annual Session at Wichita, May 19–20, Proves One of Most Successful Ever He'd

THE COMBINATION OF two good dinner and luncheon speeches, a tour of local aircraft plants, and a well-balanced series of technical papers resulted in an unusually interesting and highly informative light-plane meeting this year. Arranged and sponsored by the I.A.S. Wichita Section, the program attracted more than local interest. Representatives of the Air Force, Army Field Forces, C.A.A., and other Government agencies, as well as university and industry personnel from far-flung sections of the country, accounted for a large percentage of the attendence.

The program, which was spread over a 2-day period, consisted of a field trip to the local aircraft plants on Friday and a dinner at the Hotel Lassen in the evening. Saturday was devoted to morning and afternoon technical sessions and a luncheon at noon.

Plant Visits

An innovation in plant tours was introduced on Friday when two large Wichita Transportation Company busses drove the group through the inside of the Boeing plant. To those accustomed to inspecting production and traversing miles of assembly lines on foot, this operation "Bus Lift" was the ultimate in luxury. In 45 min. of leisurely travel the group was able to view the complete and impressive operation of Boeing's Wichita Plant 2.

This was followed by visits to Cessna and Beech facilities, after an enjoyable luncheon at Cessna's plant cafeteria. The production lines at these latter two establishments were of particular interest to this group of light-plane protagonists.

William B. Stout Proposes "Flappers"

The guests who attended the dinner at the Hotel Lassen on May 19 had the pleasure of hearing "Bill" Stout give a thought-provoking talk on the subject of flapping-wing aircraft.

One of aviation's pioneer designers and inventors, Mr. Stout has devoted years to the study of insect and bird flight. It is his firm conviction that the personal aircraft of the future will have flapping wings.

He backed his arguments by pointing out how birds—and particularly insects—take off and land with no run and can carry tremendous pay loads with practically no expenditure of energy as compared to that utilized by the modern airplane.

Of today's airplanes, Mr. Stout said: "While all personal aircraft now are good as far as they go, their possibilities are limited. Only when it can do as many things, be as generallly useful, and be as easy to own as a car, will the average man buy one . . . .

"Someone with brains, vision, and money should hire someone with brains to go after the flapping-wing problem on a scientific research basis."

William B. (Bill) Stout . . . *"personal aircraft of the future will have flapping wings."*

Technical Sessions

The morning technical sessions, consisting of two papers and an official film on the operation of liaison aircraft by the U.S. Army Field Forces, was conducted by M. J. ("Jerry") Gordon, Chief of Aerodynamics, Beech Aircraft Corporation.

Jerry H. Gerteis, Assistant Chief Engineer, Cessna Aircraft Company, acted as chairman of the afternoon session. Two more technical papers and a film on British Aircraft, shown through the courtesy of Shell Oil Company, were presented.

Since the technical aspects of these sessions are splendidly briefed on pages 16, 17, and 35 of this issue, no further report on them is necessary here.

Colonel Monroe Is Luncheon Speaker

A receptive and responsive audience of liaison - aircraft - minded listeners heard Col. Hammond McD. Monroe, Head, Air Division, Research and Development Section, U.S.A., deliver a comprehensive talk on "Army Field Forces Problems Concerning Aircraft."

After summarizing the sequence of army planning for aviation, and listing some of the problems involved, Colonel Monroe gave a detailed discussion of the three types of aircraft of most direct interest to the Field Forces. These are: Troop Carrier Planes for air-borne operations; Close Support Aircraft; and Army Organic Aircraft.

His discussion of Troop Carrier Planes was dramatically pointed-up by the showing of an official Army film on *Operation Swarmer* immediately following his talk.

Of most direct interest to the group attending this meeting, of course, was Colonel Monroe's references to Organic Aircraft. This portion of his address has been published in full as the Guest Editorial in this issue. It may be found on pages 14 and 15.

In Retrospect

Those of us who were fortunate enough to attend this meeting came away with the feeling that the light airplane is definitely here to stay. Whether it ultimately becomes a "flapper" as Bill Stout predicts or assumes some other presently unorthodox configuration, the personal airplane should become increasingly important in the years ahead.

Through continued get-togethers and discussions such as this, the advancement and development of both military and civil light planes is quickened. It is therefore fitting that we extend congratulations to the men of the Wichita Section who arranged and carried out this Seventh Annual Personal Aircraft Meeting so successfully.

W. A. S.

(*Continued from page 7*)

The last speaker of the evening, Macon C. Ellis, Jr., of N.A.C.A.'s Langley Aeronautical Laboratory, presented some results of work in the 9-in. supersonic wind tunnel, of which he is chief. He showed schlieren movies illustrating some unusual behavior of shock waves.

Dr. John M. Gallalee, President, University of Alabama, appeared at the Saturday morning session. He welcomed the visitors, expressing the gratification of the University that such a group meeting could be held there. He told of his own experience with aeronautical engineers during the recent war, expressing the belief that aeronautical engineers require knowledge of more different phases of the sciences than any other branch of engineering. He urged that students prepare themselves well in the many phases of work in their curriculums which might seem to diverge from strictly aeronautical work.

William M. Savelle, of Mississippi State College, presented a student paper on "The Economic Aspects of Private Plane Operation." He was introduced by Joe J. Cornish, III, Branch Chairman from Louisiana State University, who served as Chairman for the morning session. Savelle's paper presented an analysis of personal-plane operating cost, with breakdown into fixed and flying-time costs.

Charles T. Holbrook, T.M.I.A.S., Assistant Professor, Mississippi State College, presented some results of his work on flying-wing aircraft. He illustrated his talk with slides showing graphs and photos of his flying model. His method of obtaining stability by a combination of special airfoil section, aerodynamic twist, and use of diffuser wing tips was explained in some detail. High efficiency factors were obtained on the model, of the order of 1.02, and considerable discussion of this figure took place at the conclusion of the paper.

Chairman Cornish introduced William F. Roberts, student, University of Florida, who offered a method of cruise control worked out for a Cessna 140 personal airplane. The preparation of graphs for a particular airplane enables the pilot to select flight conditions that will improve the utility of his airplane in cruising, this being the most useful phase of operation. Though cruise-control analysis is common for large aircraft in commercial usage, the private owner too often makes no effort for the best use of the airplane according to existing wind and other conditions. Many hours are spent planning and building airplanes with good performances; therefore, time spent on cruise control is justifiable.

The meeting was terminated with a demonstration of Mississippi State College's sailplane at the Municipal Airport. Dr. Raspet provided a radio so that spectators could hear the comments of the pilot of the glider, which was towed aloft by a PT-17 and released to soar around in the clouds north of the field. The sailplane returned and landed at noon, when the group dispersed.

The Student Branch at the University of Florida, through Professor Pearson, as well as the student representatives, invited the group to meet at Gainesville in 1951. This invitation was a successful climax to an excellent First Annual Southeastern Regional Meeting.

Guggenheim Jet Propulsion Fellows

Outstanding young scientists have been granted Daniel and Florence Guggenheim Jet Propulsion Fellowships for advanced study in the fields of rocket and jet propulsion research and engineering. The Fellowships, granted for postgraduate study at Princeton University and at California Institute of Technology, have as their purpose the selection and training of outstanding young men for basic research and for leadership in the development of peacetime commercial and scientific use of jet and rocket propulsion. Each Fellowship carries an annual stipend of $2,000.

At Princeton, the Guggenheim Fellowships have been granted to:

▸ **Clarence B. Cohen,** T.M.I.A.S., a 25-year-old naval veteran who has served as an Aeronautical Research Scientist at the N.A.C.A. Lewis Flight Propulsion Laboratory, Cleveland.

▸ **David H. Ross,** 22-year-old member of the Class of 1950 at Sibley School of Mechanical Engineering, Cornell University. In 1947, Mr. Ross completed nearly 2 years with the Army Transportation Corps. He is a member of the I.A.S. Student Branch at Cornell.

Among those named by CalTech are:

▸ **Thomas C. Adamson, Jr.,** 26, an I.A.S. Student Member, who is currently employed part-time at CalTech Guggenheim Aeronautical Laboratory. He served 15 months overseas with the U.S. Army.

▸ **Robert V. Meghreblian,** M.I.A.S., 27, who is receiving the grant a second time. He left the CalTech Jet Propulsion Laboratory last year to accept the new Fellowship and will continue his work at the Laboratory during the coming year.

▸ **David E. Shonerd,** 27, a Student Member of the I.A.S., who received his undergraduate training at California Institute of Technology and is currently an Engineering Analyst at the CalTech Jet Propulsion Laboratory. During the war he served in the Navy and worked in 1943–1944 on the CalTech rocket project. He has also worked as a Wind Tunnel Engineer at the Southern California Cooperative Wind Tunnel.

John C. Leslie Appointed to New P.A.A. Posts

In addition to having been elected a Director of Pan American World Airways System, John C. Leslie, F.I.A.S., has been appointed Vice-President of Administration. Graduating from Princeton in 1926 and from Massachusetts Institute of Technology in 1928 as an aeronautical engineer, he joined Pan American's engineering staff in January, 1929. Except for a year on leave at M.I.T. in 1931–1932 as an Alfred P. Sloan, Jr., Fellow in Business and Engineering Administration, he has been with the P.A.A. ever since.

As Division Engineer for the Pacific Division in 1935, he developed the engineering technique for long-range flight which made possible the first

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John C. Leslie, F.I.A.S., newly chosen Director and Vice-President of Administration of Pan American World Airways System.

commercial air service across the Pacific. Subsequently, he was Operations Manager of the Pacific Division. During World War II, he managed the company's Atlantic Division, where he was responsible for Pan American's extensive wartime operations to Europe and Africa. In 1945 he was made Vice-President in Charge of the Atlantic Division and in August, 1946, was transferred to the staff of Juan T. Trippe, President of Pan American, at System Headquarters in New York.

Jetliner Establishes New Record

The Jetliner, manufactured by A. V. Roe Canada Limited, flew the first jet transport air mail on April 18 when it established a Toronto–New York transport record of 59 min. Flown by Capt. Don Rogers, M.I.A.S., Chief Test Pilot at Avro Canada, the international flight cut about 46 min. from the present direct air-line time for the 370-mile run. Although most of the flight to New York City was accomplished at 20,000 ft. as a special safety measure until tests at higher altitudes had been completed, it is expected that "the aircraft normally will cruise at 30,000 ft.—well above dangerous icing conditions." Among the passengers was James Floyd, M.I.A.S., Assistant Designer, Avro Canada.

Powered by four Derwent 5 turbojet engines, each with a thrust of 3,600 lbs. at a compressor speed of 14,700 r.p.m., the Avro Jetliner can carry a fuel load of about 2,400 gal. By feeding a special mixture of water and methanol into the engines during take-off, thrust is increased to 4,000 lbs.

The Jetliner, with a capacity of 40 to 60 passengers, has a wing span of just over 98 ft. and measures 26½ ft. from the top of the fin to the ground.

Brown University to Hold Symposium on Plasticity

The Third Symposium on Plasticity will be held on September 8 and 9, 1950, under the auspices of the Graduate Division of Applied Mathematics at Brown University, Providence, R.I.

American and foreign experts in the field will present papers covering their most recent experimental and analytical research on "Stress-Strain Relations" and "Problems and Methods in the Analysis of Structures and Continuous Media." Institute members are invited to participate in the discussion. For further information, please write to Prof. D. C. Drucker, Brown University, Providence 2, R.I.

Wings Club Elects Officers

C. S. (Casey) Jones, A.F.I.A.S., President, Academy of Aeronautics, La Guardia Airport, has been elected to serve a 1-year term as President of the Wings Club. Mr. Jones has been intimately concerned with aviation ever since he was a pursuit pilot in World War I. At one time he was President of the Curtiss-Wright Flying Services.

Orval M. Mosier, A.M.I.A.S., Vice-President, American Airlines System; Roger Wolfe Kahn, M.I.A.S., Grumman Aircraft Engineering Corporation; and Rear Adm. L. B. Richardson, U.S.N. (ret.), F.I.A.S., were elected as Vice-Presidents of the Club.

Necrology

Frank A. Tichenor

Frank A. Tichenor, A.M.I.A.S., died suddenly on May 4 at his home in Greenwich, Conn., after a brief illness. He would have been 70 on May 22.

▸ **Magazine Publisher**—Mr. Tichenor's interest in aviation began when he acquired *Aero Digest* in 1922. Seven years later he bought Henry Ward Beecher's celebrated magazine *The Outlook*, and under the name *The New Outlook*, with the late Alfred E. Smith as Editor, he began reissuing it as a monthly. Shortly thereafter he became publisher of *The Spur*, an international society and sports magazine, and of *The Plumbing and Heating Trade Journal*. Meanwhile he augmented his keen appreciation of aviation with *The Sportsman Pilot*, devoted to sports aviation, and by establishing *Revista Aerea*, a Spanish edition of *Aero Digest* directed to Latin America. In later years he concerned himself with the publication of the weekly *Letter to Airmen*.

▸ **Fighter and Organizer**—There was scarcely an important figure in aviation who did not know Frank Tichenor on intimate terms and who did not know him as an indefatigable fighter for the good of the industry. A champion and close friend of the late Brig. Gen. Billy Mitchell, he denounced the contract cancellations and continued his attack after the Washington Congressional investigations had failed to disclose justification for so drastic a step. Subsequently, Mr. Tichenor established the Billy Mitchell Award, bestowed in the form of a bronze plaque for outstanding services to aviation.

He was Founder and Past-President of the Wings Club, international organization of persons well known in aviation, and served on the Board of Governors until his death. He belonged to the Conquistadores, exclusive order in aviation and, in 1944, was made an honorary member of the Early Birds. He was also President of the Civil Air Patrol League. In 1949 he was the recipient of the William J. McGough Memorial Award, bestowed by Air Service Post 501 of the American Legion.

News of Members

▸ Commissioned.. **William C. Becker,** T.M.I.A.S., has been commissioned a Second Lieutenant, Pilot, in the U.S. Air Force. Lieutenant Becker was one of four cadets in a class of 54 who were recommended to receive regular Air Force commissions.

▸ Director...**Wellwood E. Beall,** F.I.A.S., Vice-President, Boeing Airplane Company, was elected to a 3-year term as a Director of the Conquistadores del Cielo, social organization of the aviation industry.

▸ Instrument Flight...The helicopter pilots of the Los Angeles Airways, Inc., of which **Clarence M. Belinn,** M.I.A.S., is President, have been authorized for night flying on instruments in thin "smog" layers for periods not exceeding 15 min.

▸ Board of Directors . . . **Arch T. Colwell,** A.F.I.A.S., Vice-President and Director of Engineering, Thompson Products, Inc., and Chairman of the I.A.S. Cleveland Section, has been elected a director of Jack & Heintz Precision Industries, Inc.

▸ Retiring . . . **F. Trubee Davison,** M.I.A.S., has announced his decision to retire by October, 1951, from the presidency of the American Museum of Natural History, New York, bringing his period in office to 18 years.

▸ Director . . . The Conquistadores del Cielo, aviation social organization, have elected **Charles W. Deeds,** A.M.I.A.S., Hartford, Conn., as a Director for a 3-year term.

▸ Research Program . . . **Dr. Maurice A. Garbell,** A.F.I.A.S., President and Director, Garbell Research Foundation, San Francisco, is directing a research program on the investigation of airport acceptance rates under contract between the Foundation and the U.S. Weather Bureau. The program, sponsored by the Air Navigation Development Board, has as its principal objective the determination of the quantitative effect of meteorological parameters (cloud masses, wind, etc.) on the "acceptance rate" or operational capacity of typical crowded airports.

▸ Hiller 360 . . . **Stanley Hiller, Jr.,** T.M.I.A.S., has announced the delivery of the 1950 Utility Hiller 360 and the addition of the Hiller 360 Executive to the Hiller line. The three-place Utility 1950 Hiller 360, powered with a Franklin engine, has a gross weight of 2,400 lbs., with a useful load of 968 lbs.

▸ New Book . . . John Wiley & Sons, Inc., published last April a new fourth edition of *Elements of Practical Aerodynamics* by **Bradley Jones,** A.F.I.A.S., Professor, Aeronautical Engineering, University of Cincinnati. The new edition contains many illustrative problems, together with step-by-step solutions emphasizing simplicity in treatment. Detailed discussions of ideal fluid, vortex motion, circulation, boundary layer, speed of sound, and *V-g* diagrams have also been added to the new edition.

▸ Helicopter to Turkey . . . The Kaman Aircraft Corporation, **Charles H. Kaman,** M.I.A.S., President, has delivered a K-225 Helicopter to Turkey where it will be utilized in agricultural work and possibly for patrolling remote areas and for air-mail service to mountain areas. A pilot and mechanic accompanied the aircraft to train the Turkish personnel in its operation and maintenance.

▸ Board Member . . . **Richard Markey,** M.I.A.S., General Manager, Penmarva Electric Manufacturing Company, Inc., has been elected a member of its Board of Directors.

▸ Director . . . **John W. Myers,** M.I.A.S., Vice-President, Northrop Aircraft, Inc., has been elected a Director of the Conquistadores del Cielo for 3 years.

▸ Board Chairman . . . **Frank N. Piasecki,** T.M.I.A.S., formerly president of Piasecki Helicopter Corporation, was elected to the newly-created post of its Chairman of the Board. Mr. Piasecki will also continue to serve as Director of Research and Development for the company.

▸ Admitted to Membership . . . **Arthur E. Raymond,** H.F.I.A.S., Vice-President of Engineering and Director, Douglas Aircraft Company, Inc., was elected to membership in the National Academy of Sciences. He was President of the Institute of Aeronautical Sciences in 1946.

▸ Deicing . . . A lighter and possibly more efficient system for deicing wing surfaces of jet airplanes has been developed by **Dr. Myron Tribus,** M.I.A.S., Engineering Department, University of California at Los Angeles. Dr. Tribus' system utilizes intermittent heating and takes advantage of the heat liberated by the formation of ice.

▸ Receives Medal . . . **Gill Robb Wilson,** M.I.A.S., aviation columnist, *New York Herald-Tribune,* received the Aviators' Post Gold Medal. The citation that accompanied the annual award praised Mr. Wilson for "distinguished service in aviation journalism."

▸ Executive Engineer . . . **Harold W. Zipp,** M.I.A.S., has been appointed Executive Engineer, directing all engineering administration and staff activities for the Wichita Division, Boeing Airplane Company.

National Meetings Calendar

July 12–14	Annual Summer Meeting, Los Angeles
December 16	Wright Brothers Lecture, Washington, D.C.
Jan. 29–31, Feb. 1, 1951	Nineteenth Annual Meeting, New York

For details see page 29

Attention Members!

All members of the Institute are invited to submit material concerning their activities for publication in the "News of Members" columns of the *Aeronautical Engineering Review.* Responsibility for new developments, awards or honors received, and appointments to new or additional positions are some of the items that your editors believe are of interest to other I.A.S. Members. A brief letter or postal card giving exact details will be sufficient. Photographs accompanying news items will be welcomed and will be used where practicable.

Items submitted will be considered on the basis of their timeliness and general interest. Correspondence should be addressed to the News Editor, *Aeronautical Engineering Review,* 2 East 64th Street, New York 21, N.Y.

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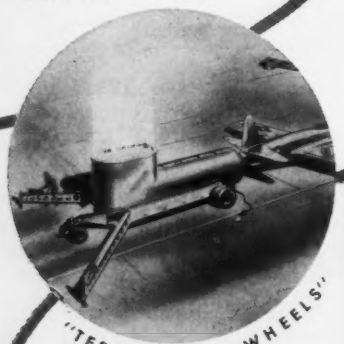

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Corporate Member News

• Pressurization. . .**AiResearch Manufacturing Company** is supplying the complete pressurization and air conditioning for 65 Martin 4-0-4 transports ordered by Eastern Air Lines, Inc., and Trans World Airlines, Inc., and for 272 Grumman F9F Navy Fighters. Deliveries are scheduled for completion during 1951. . .United Air Lines, Inc., is replacing all original cabin-pressure safety valves on DC-6's with AiResearch safety valves. Fifty-six units are scheduled for delivery in early summer.

• New Quarters. . .The executive staff and general office personnel for the non-operating departments of **American Airlines System** and **American Overseas Airlines, Inc.,** have moved their headquarters to 100 Park Ave., New York. . .The Board of Directors of American Airlines declared the regular quarterly dividend of $0.875 per share of preferred stock payable to June 1 stockholders of record at the close of business May 16. . .During the first 10 days of operation of deluxe coach service by American Airlines, 86.4 per cent of all available seats were sold.

• Beechcraft Dividends. . .A quarterly dividend of 20 cents a share was voted on April 25 by **Beech Aircraft Corporation,** to be paid on May 22 to stockholders of May 8.

• Turbo Fuel Pump. . .One of the four X-1A's being built for the Air Force by **Bell Aircraft Corporation** will have a turbo fuel pump to force alcohol and oxygen into the burner chambers of the Reaction Motors rocket engine. This system will provide greater flight endurance and speed. Design speed is rated at 1,700 m.p.h. . . .The original X-1, which has nearly completed its flight-test work, will soon be shipped to the Smithsonian Institution in Washington.

• New Spark Plugs. . .**The BG Corporation** is producing new unshielded, ceramic-insulated, resistor spark plugs, Model 706R, for use on Continental A50, A65, A75, C75, and C85 engines powering personal aircraft.

• New Model Bomber. . .U.S.A.F. has ordered the new Model C-97 Stratofreighter troop and cargo transports from **Boeing Airplane Company.** The plane, which will incorporate greater loading facilities than the C-97A, will be powered with four Pratt and Whitney 3,500-hp. Wasp Major engines. It will have a top speed of over 375 m.p.h. and a service ceiling of over 35,000 ft. The new C-97 is designed to carry 136 fully equipped troops. . .The first completely modified RB-50B multipurpose bomber has been delivered to the Air Force by Boeing Airplane Company. In addition to its use as a normal strategic bomber, it will double as an aerial photographic and weather reconnaissance "laboratory," with nine camera mounts and modern weather recording devices. . .Boeing Airplane Company has integrated its Seattle and Wichita engineering divisions into a single unit.

• First Test Flight. . .**Consolidated Vultee Aircraft Corporation** has conducted the first test flight with an engine nacelle carrier hung externally from a B-36's bomb bays. The carrier will enable a B-36 to haul four of its own spare power plants to bases where they may be needed and, when loaded, will weigh approximately 25,000 lbs. . . .Delta-wing XF-92A, Air Force experimental jet fighter, has been returned to Consolidated Vultee Aircraft Corporation's San Diego plant for modifications to give the plane more power before continuing flight-test work. A later-model, higher-thrust version of the Allison J-33, equipped with an afterburner, will replace the present J-33. . .First take-off and landing of an XB-36 equipped with a caterpillar-type track landing gear was made by the Fort Worth Division of Consolidated Vultee Aircraft Corporation. The gear, which is retractable, is designed for a maximum average pressure of 57 lbs. per sq.in. on the landing strip.

• DC-6's. . .The delivery to United Airlines, Inc., of five DC-6 Mainliners, produced by **Douglas Aircraft Company, Inc.,** increases United's DC-6's to 45 and the fleet total to 148 planes. Five larger DC-6B's are expected to be delivered early in 1951.

• New Order. . .**Eastern Air Lines, Inc.,** has ordered ten Super-New-Type Constellations from the Lockheed Aircraft Corporation. The purchase was made at a cost of $18,000,000 (with spare parts and engines) or over $1,500,000 each for the plane alone. Capable of carrying 92 passengers, the plane will cruise at 330 m.p.h. and will be powered with four Wright CA-1 engines developing a total of 11,000 hp. Delivery is expected to begin about the fall of 1951.

• Nut Strip. . .A new gang channel nut strip, to provide permanent fasteners for applications subject to repeated "on-off" usage, has been introduced by **Elastic Stop Nut Corporation of America.** The nylon red-elastic locking collar is designed to assure self-locking torque for the life of an aircraft and protect fastenings against vibration, impact, and shock.

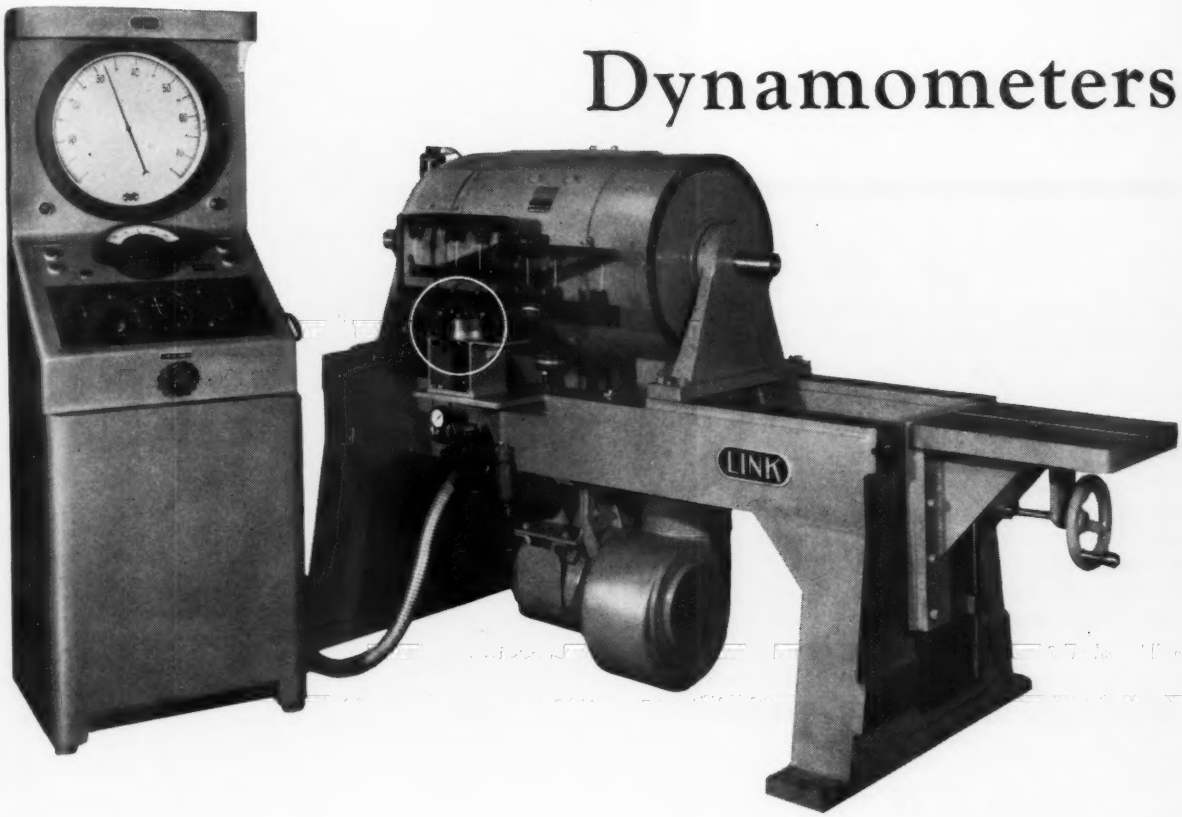
• New Home. . .**The Ethyl Corporation** has moved its offices to 100 Park Ave., New York.

• Plotting Table. . .**The Fairchild Camera & Instrument Corporation** has developed a new precision plotting table for accurate and rapid plotting or measuring of points on a plane surface in terms of rectangular coordinates whose values are registered on Veeder-Root-type counters to the nearest 0.001 in. It was designed primarily for precise topographical layout work.

• Jet Reheat Engine Tested. . .The reheat jet engine with a clamshell nozzle at the end of the tailpipe, developed by the Aircraft Gas Turbine Division, **General Electric Company,** is being test-flown in the North American F-95A, a higher flying and extensively modified version of the F-86 jet fighter. Another experimental reheat power plant has also been tested in the Republic XF-91. . .Developed by General Electric Company's General Engineering and Consulting Laboratory for use in the

(*Continued on page 76*)

HAGAN THRUSTORQ in LINK Dynamometers



This series of Electric Dynamometers, developed by Link Engineering Company, Detroit 27, was specifically designed to utilize the advantages of Hagan THRUSTORQ as a thrust-measuring element.

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A Guest Editorial by Col. H. McD. Monroe U.S.A.

What Army Expects of Light-Plane Manufacturers*

On the subject in which you gentlemen are most interested, I should like to speak of "organic" aircraft (aircraft that are operated as an integral part of ground force organizations—i.e., not operated by the Air Force). This subject was discussed in great detail at your meeting last year by representatives from Army Field Forces whose comments were published in your magazine.

I should like to bring you up to date on the current trends in this field. At your meeting last year, the Army Field Forces speakers pointed out that:

(A) Organic aircraft have proved themselves most useful and have become a permanent part of the Army. There are approximately1,200 such aircraft being operated by the Regular Army and National Guard.

(B) Army aircraft operated from unprepared strips with little or no maintenance facilities must be more ruggedly constructed than their civilian counterparts.

(C) Because of lack of funds, the Army must buy commercial aircraft "beefed" up to take the daily beating encountered in Army use.

(D) Procurement of commercial aircraft by the Army benefits the industry and ensures the Army relatively unlimited quantities in the event of hostilities.

(E) Army research and development funds, being insufficient for development of complete aircraft, would be channeled into development of improved aircraft components, such components to be available for use by commercial aircraft designers.

In the year that has passed, the Army has been able to budget for the research and development of its organic aircraft and to obtain funds to procure a limited number of service test aircraft. As was expected, sufficient money was not forthcoming to develop tailor-made aircraft. However, we have funded to develop components for light aircraft that we hope will be sufficiently attractive to cause their utilization by designers of personal aircraft. These include such items as the light gas turbine, improved propellers, deceleration devices, and lightweight accessories. We are currently completing an evaluation of two-place tandem and high-wing aircraft for Army procurement. The results of this evaluation showed that the light aircraft industry paid close attention to the features pointed out as being desired by the Army in the talks last year. We have been very, very pleased with the results of this evaluation. In addition, we have been able to procure helicopters for service tests. I think that we have established a precedent that can be continued in the future. Congress has been sympathetic to our requirements, and our policy of buying commercial equipment modified to meet our requirements can be expected to continue. We are cooperating closely with the Air Force, and the Air Force in turn has proved it is fully capable of filling our requirements.

* Excerpts from Address given at Seventh Personal Aircraft Meeting, Wichita, Kan., May 20, 1950, by Col. H. McD. Monroe, U.S.A.

Technical Sessions at Wichita

KENNETH RAZAK*
University of Wichita

Kenneth Razak *(left)* with Chairman of the Morning Session Jerry Gordon *(center)* and Speaker F. M. Rogallo *(right)*.

THE TECHNICAL SESSIONS OF THE Seventh Annual Personal Aircraft Meeting might well have been a continuation of the Sixth Annual Personal Aircraft Meeting, in that the theme of the meeting was an extension of the theme, "work and progress," which had been previously exhibited. The description of the specifications of a new agricultural and dusting airplane by Fred Weick, together with the introduction of new research on boundary-layer control, emphasized the intent of the personal aircraft enthusiasts to expand and improve the utility and operating efficiency of personal aircraft.

The technical papers delivered on Saturday, May 20, were adequately pointed up by "Bill" Stout at the banquet the night before, in which he pointed out the possibilities that existed and the fundamental thinking that is required to produce aircraft that would provide the degree of utility now provided by the automobile. It was inevitable that he should turn to the evidences of Mother Nature in her flying machines for direct illustration of methods that could be used for vertical take-off and vertical landing. His conclusion that flapping wings could well be considered by many aeronautical engineers was received in various fashions throughout the group with some rather pointed remarks directed toward certain deficiencies in Mother Nature. While none of the papers went so far as the remarks of "Bill" Stout, there was great evidence of forward thinking and continued work to produce a better product.

The first paper of the session was delivered by Francis M. Rogallo, of the Stability Research Division, Langley Aeronautical Laboratory, N.A.C.A. Mr. Rogallo's paper described three combinations of aileron and flap which could be used for lateral control of low-speed aircraft. While none of his material represents recent and continuing experimentation, it is an adequate summary of configurations that are now available to the personal airplane designer for his use in personal aircraft.

Combinations presented in his paper were: (1) plain and slot-lip ailerons on a wing with a full-span slotted flap; (2) plain aileron with full-span slotted flap retracting ahead of it; and (3) N.A.C.A. plug aileron on a wing with a full-span slotted flap.

No particular advantage of one of these combinations over another was cited, but all were presented as possible combinations for improvement of lateral control and for making possible the reduction of landing speed through utilization of full-span flaps. Detailed considerations were discussed, such as the necessity of ventilating the slot in which the plug aileron moved. Such ventilation was found to be necessary to produce effectiveness at small deflections of the plug-type aileron. One of the most distinct impressions secured from Mr. Rogallo's discussion was the extreme necessity of adhering to published design material or face the necessity of undertaking an experimental and development project for any different configurations. The dangers of modifying the configurations that have been tested were emphasized. Small changes were capable of materially altering the effectiveness and feel of slot-lip and plug configurations, and the N.A.C.A. has many cases where such alterations produced unsatisfactory results. It appears that this problem may not be so serious on the smaller and lower speed aircraft, but certainly the personal airplane manufacturer who strives for an easy-to-fly, simple airplane must be extremely cautious before designing a configuration such as was proposed and offering it to the general public.

Questions from the floor, following Mr. Rogallo's paper, emphasized the feeling of caution. Representatives of aircraft manufacturers questioned the item of control feel, and the answer was that a specific configuration study was required in every case. This, of course, means a development program. Feeler ailerons were not necessarily required, in the opinion of Mr. Rogallo, although they had been used in certain installations, particularly those pioneered by Northrop. Fred Weick discussed a possible configuration that is being studied for adoption on the agriculture airplane on

* Director, School of Engineering.

which he is working. This involves a combination of drooped flap with slot-lip aileron, and he is hopeful for the result but somewhat apprehensive of the work and complication involved. The discussion closed on a final note of caution concerning the adoption of these methods of lateral control because of the extreme variety of arrangements that are possible. (Mr. Rogallo's paper will appear in the August issue of the REVIEW.)

Your author was fortunate enough to be able to discuss research work on low-speed flight which is now being conducted at the University of Wichita. This research, being sponsored by the Office of Naval Research, is a study of the effects of boundary-layer control on the aerodynamic characteristics of wing sections. The paper was devoted to a description of the efforts that had been made to survey the field, with emphasis on the study of captured German documents. Reference was made to aircraft that had been designed and flown in Germany as early as 1941 and which showed the definite utility of forms of boundary-layer control. The wide variety of testing performed, however, together with the difficulty of gathering all material and properly cataloging it, has made it difficult to secure a complete and overall picture of the field of boundary-layer control so that sufficient material could be furnished to provide design procedures. It was this deficiency that the research project at the University of Wichita is attempting to remedy.

The paper presented a description of the testing facility, including the 7- by 10-ft. wind tunnel and the particular installation of the test airfoils in the wind tunnel. Tests were conducted on an airfoil of 4-ft. span, mounted between end plates, operating at an effective Reynolds Number of somewhat over 2,500,000. The airfoil section of NACA 23015, using a slotted flap and a hinged nose, was chosen, since some data were available on this section from German research. Boundary-layer control was secured by blowing air from slots located immediately behind the hinged nose on the upper surface of the profile and from a slot blowing over the upper surface of the deflected flap.

The air was supplied for the blowing tests by a 65-hp. blower, which was capable of being independently controlled both as to the quantity of air delivered and the pressure ratio. Values of blowing ratio were varied from nose to flap slot, and it was found that the major improvement could be secured by directing all of the air to the slot at the flap.

The hinged nose on an airfoil of 15 per cent thickness was found to be of little value with or without boundary-layer control. Its prime effect was merely to extend the stall angle, but it did not increase, and in some cases even decreased, the maximum lift coefficient. With blowing out over the flap only, maximum lift coefficients of about 4.4 were secured. These lift coefficients were accompanied by actual negative drags, which, of course, were offset by the quantity of power required to furnish the blowing air. From an auxiliary standpoint, however, this negative drag provides the possibility that airplane performance on take-off and landing at high angle of attack and high lift coefficients might be materially improved. Preliminary calculations show that 40 per cent reductions in take-off run and 60 per cent reductions in landing run can be possible if the full value of boundary-layer control is utilized.

Detailed charts and graphs were presented which showed the test results indicating the value of blowing out from slots of different widths and with flap in different positions. The paper was concluded by speculating upon the possibility of tremendous improvement in lateral control which could be made possible by the prevention of airflow separation over flaps deflected to angles of 50°. The rate of change of life coefficient with flap deflection was maintained at an extremely high value for these high flap deflections, and the possibility of using drooped ailerons down as far as 30°, with still adequate lift coefficient change available for further flap deflection, makes it possible to use both the high lifting properties and control characteristics of a deflected flap arrangement.

Following a luncheon, at which Col. Hammond McD. Monroe, U.S.A., presented points that were of importance in the selection of aircraft as far as the ground forces were concerned, a paper written by Earl Weining, Project Engineer, Boeing Airplane Company, was presented by Doug Heimberger, of Boeing, on the development of the L-15 liaison airplane, as well as an analysis of the effects of certain variations in specifications upon performance and design. This paper, which is a condensation of work that has been in progress for almost 2 years, represented, even in a condensed form, a great compilation of statistical and derived information, much of which can be appreciated only by detailed study.

The description of the design and development procedure highlighted the problems of development, such as the selection of an adequate propeller, the difficulty of securing adequate altitude performance as a result of carburetor difficulties, and the problems encountered in securing adequate directional and lateral control. This latter difficulty required the use of retractable ailerons or spoilers and the installation of larger rudder surfaces. The initial part of the paper stressed the fact that the airplane was designed as a handbook airplane to a particular set of specifications. One of these specifications, a landing speed of 35 m.p.h., was pointed out as the major factor in contributing to some of the performance limitations and deficiencies that were finally found to exist. The necessity of providing sufficient wing area and flap arrangements to secure this low landing speed imposed rather severe penalties on other aspects of the design, particularly upon ceiling and rate of climb. In trying to summarize the material describing the development of the L-15 airplane, it is almost impossible to discard one point in favor of another point, and obviously much attention has been given to the relative value of descriptive points in the initial writing of the paper.

(*Continued on page 35*)

Design Factors in the Development of Light Aircraft

EARL WEINING*

Boeing Airplane Company

Introduction

THE "MILITARY CHARACTERISTICS" or type specification requirements have a marked influence on the tactical suitability of an airplane design because they define the mission of the airplane, the minimum and desired performance, the minimum equipment requirements, and other criteria pertaining to tactical requirements. It follows that the activity originating the military requirements is largely responsible for the success or failure of the airplane as a tactical unit.

The success of a design depends on an intelligent compromise of many factors. Such a compromise cannot be the complete responsibility of the designer. The relative importance of various design factors (such as airplane size, performance, and equipment) can be established only by the customer.

Type Specification Requirements

Rigid type specification requirements must be held to a minimum to permit flexibility of design. When a particular need exists but is not an absolute "must," it should be designated as a desired item or as a goal to be achieved without serious compromise to more important factors. A low landing speed, such as 25 to 35 m.p.h., for example, is not particularly important or even desirable. The important factor is landing distance. A 600-ft. landing over a 50-ft. obstacle onto a sod surface can be achieved with stalling speeds ranging from 35 to 50 m.p.h., depending on airplane drag, which in turn is largely a function of the amount of flap area carried. With such a choice of stalling speeds, the governing criteria, insofar as liaison aircraft are concerned, becomes the desired observation speed.

The original Army military characteristics to which the L-15 was designed required that the landing speed not exceed 35 m.p.h., a minimum rate of climb of 600 ft. per min., and a maximum take-off or landing distance of 600 ft. The 35-m.p.h. landing speed can definitely be met with a 35 m.p.h. power-off stalling speed, provided control is adequate. An average airplane meeting the fixed-load requirements of the type specification and the minimum rate of climb and having a 35-m.p.h. stalling speed will require 130 hp. and will weigh 2,100 lbs. In the most recent liaison airplane "military characteristics," the landing-speed requirement has been replaced by an observation speed range from 40 m.p.h. desired to 50 m.p.h. maximum. This observation speed can be achieved with a 40-m.p.h. power-off stalling speed. The fixed-load requirements have been increased by 23 lbs.; the required endurance has been increased by 1 hour; the minimum rate of climb has been increased to 800 ft. per min.; and, at the same time, the span limitation has been reduced from 40 to 37 ft. The effect of these changes is interesting (see

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* Project Engineer, Wichita Division.

TABLE 1
Effect of Specification Changes on Performance

	Power	Span	Weight	R/C	Take-Off
Original type specification airplane	130	40	2,100	600	550
Reduce span to 37 ft.	130	37	2,100	470	880
Increase fixed weights 23 lbs.	130	37	2,141	424	975
Increase endurance by 1 hour	130	37	2,220	342	1,210
Increase stalling speed from 35 to 40 m.p.h.	130	37	2,159	593	700
Increase power to obtain specified minimum R/C of 800 ft. per min.	225	37	2,772	800	520

Table 1). Obviously, the majority of the revisions to the original type specification have been in the direction of a larger, heavier, more powerful (and, therefore, more costly) product. At the same time, the specification stated that an airplane with an empty weight of 1,000 lbs. was desired.

WEIGHT DATA

Weight data for this study have been based on a careful analysis of the component weights of five liaison aircraft and five light commercial airplanes. Fixed-equipment weights were established by the specification. It is impossible at this time to enter into a complete presentation of this weight analysis; however, a few typical curves will serve to demonstrate the nature of the study. Such typical curves are represented by body structure weight in Fig. 1, engine section weight in Fig. 2, empennage weight in Fig. 3, and wing weight in Fig. 4. The K factor in the latter two curves is representative of per cent flap area. The fixed weights are summarized in Table 2. The designer can exercise only limited control over 6 per cent of the total, 758 lbs. shown in Table 2. For example, wiring, conduit, clips, etc., under electrical equipment are well fixed by the specification and the airplane size. Pilot's seats for liaison aircraft range in weight from 7.0 to 8.6 lbs. for that in the L-15. The L-15 seat is designed for a 40g crash load and is equipped with inertia-locking shoulder harness reel weighing 1.5 lbs. Observer's seats range in weight from 2 lbs. for that in the L-6 (a plywood panel), to 11.5 lbs. for the 10g, 180° swiveling seat in the L-15. (If the swiveling seat were eliminated, it would, under present requirements, be necessary to add shoulder harness and reel and to design for a 2,000-lb. harness load. A fixed seat of approximately 7 lbs. weight, plus 4 lbs. for harness and reel, would weight 11 lbs.) The

TABLE 2
Summary of Fixed Weights

Electrical equipment	98.7
Instrument installation	17.1
Furnishings	55.8
Starting system	21.0
Communicating equipment	100.0
Crew weight	400.0
Propeller weight	65.0
Total	757.6

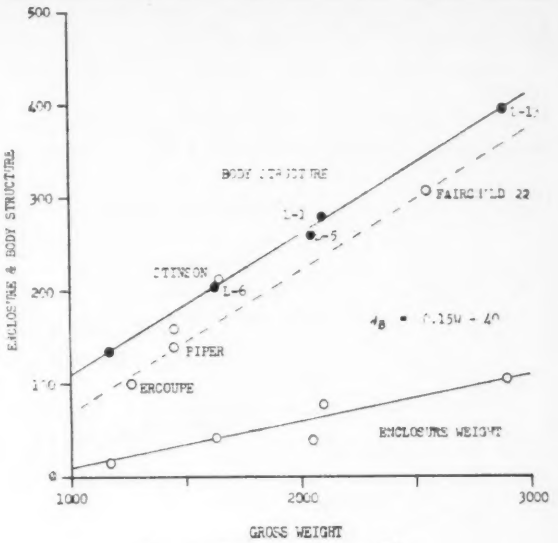


FIG. 1. Body structure weight.

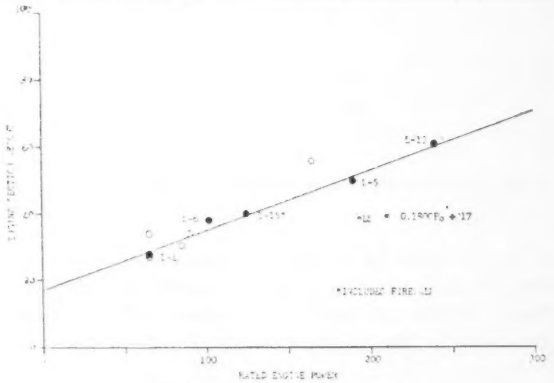


FIG. 2. Engine section weight.

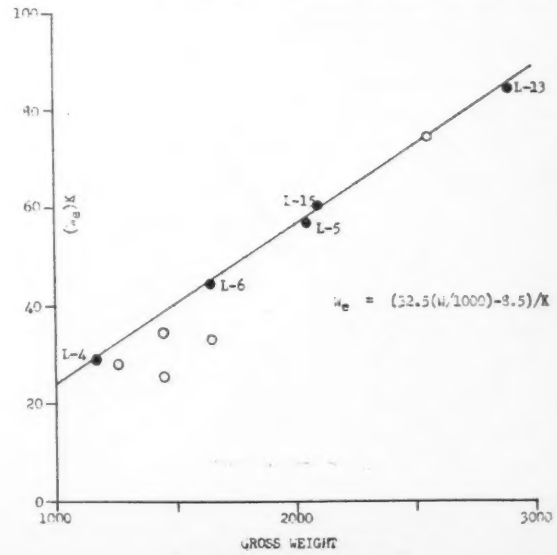


FIG. 3. Empennage weight.

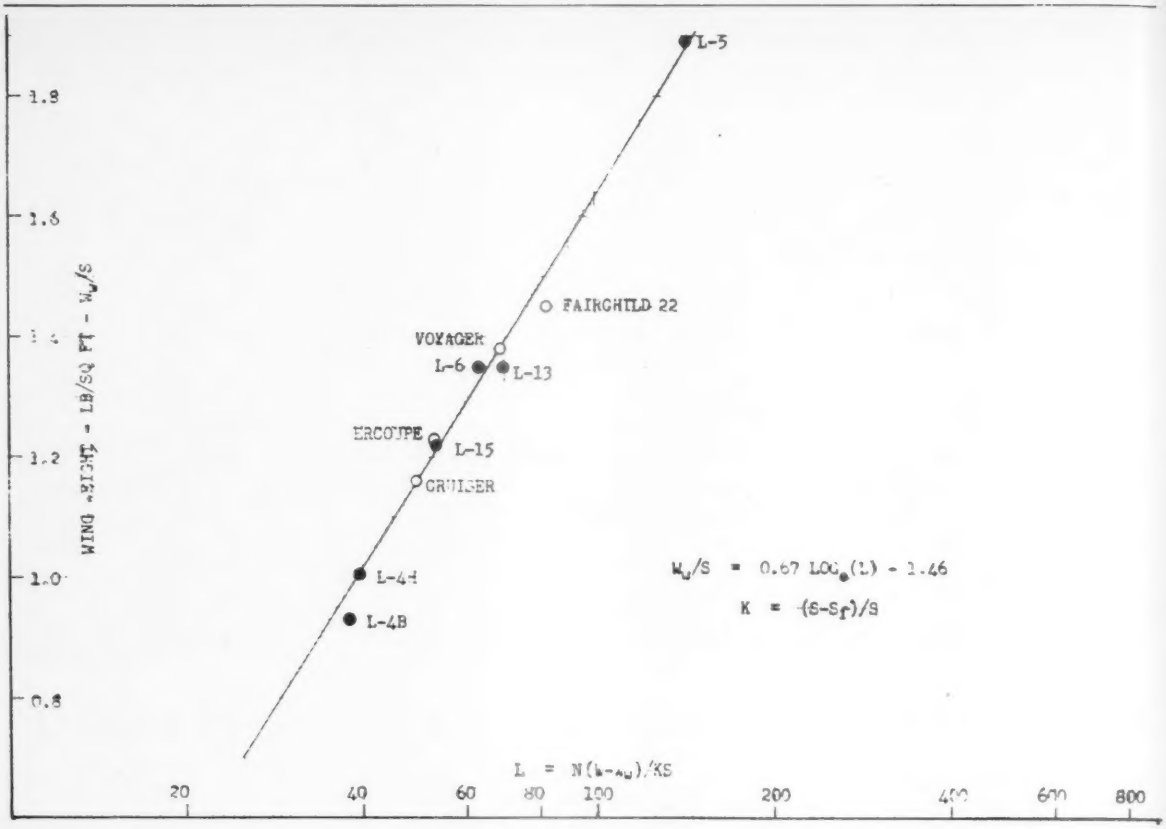


FIG. 4. Wing weights.

65-lb. allowance for propeller is representative of available metal constant-speed units. Since all of the component weights are functions of power and/or airplane gross weight, the airplane weight can be reduced to a simple function of power if wing loading, endurance, and load factors are held constant. The resulting relationship has been shown to be accurate to within plus or minus 2 per cent for liaison aircraft. It is easily modified to fit any given set of conditions. This weight analysis has shown that the airplane weight is not affected by the amount of flap area used if a constant stalling speed is maintained. It has also shown that there is no essential weight difference between military liaison aircraft and the off-the-shelf adaptions for equal fixed-load requirements, equal flotation, and equal load factors. There is no sacrifice weightwise from all-metal construction or cantilever wings.

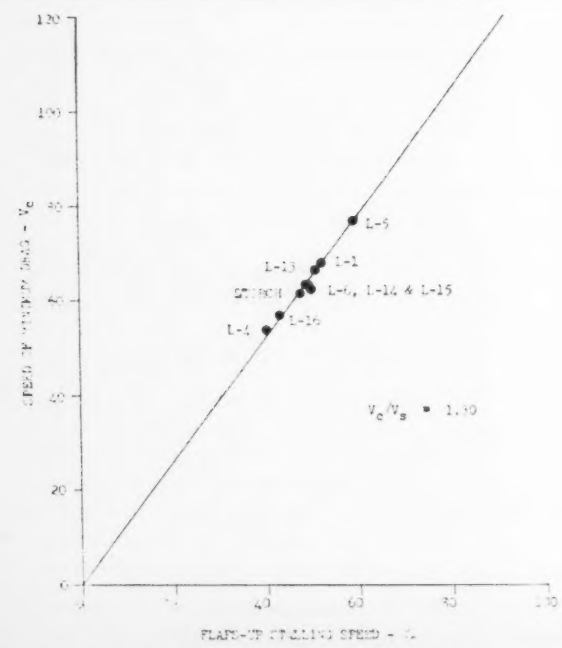


FIG. 5. Speed of minimum drag vs. stalling speed.

PERFORMANCE DATA

Performance data for the study were based on those for ten liaison aircraft, the Fiesler Storch, and a modified Fairchild "22." All performance data were actual flight-test figures. Here, again, it is only possible to cover briefly this phase of the study; however, it can be stated that climb data computed on the basis of the development were accurate to within plus or minus 3 per cent and the high speed to within approximately plus or minus 1 per cent for the airplanes studies. It has been shown that the speed of minimum drag, which is also the speed of best climb, is a direct function of the flaps-up stalling speed. In the case of liaison aircraft, this ratio, as shown by the curve in Fig. 5, is equal to 1.3. Since at the speed of minimum drag the parasite and

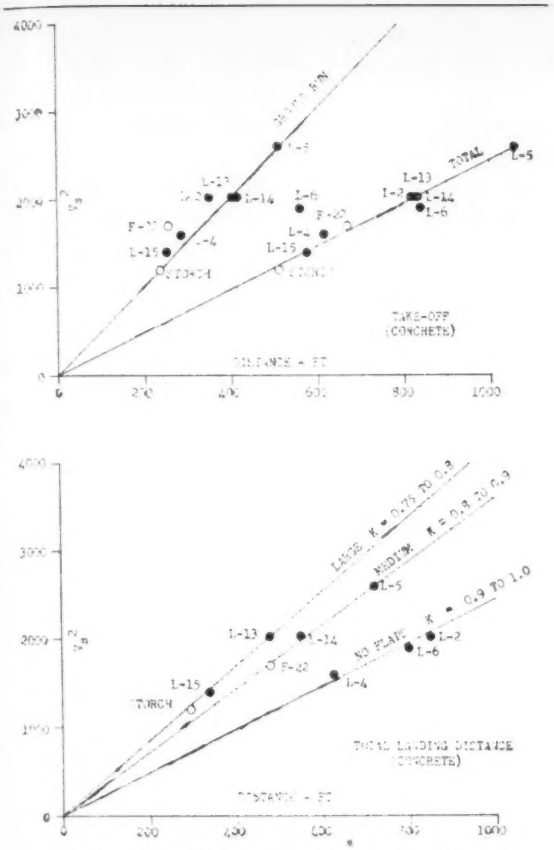


FIG. 6. Take-off (*top*) and landing distances (*bottom*).

induced drag are equal, this leads to an interesting method of predicting performance which is versatile and well adapted to changes in parameters. Take-off distance was found to be a simple function of stalling speed and rate of climb (see Fig. 6). Here, all actual distances have been reduced to a common rate-of-climb basis of 600 ft. per min. by the ratio of actual rate of climb to 600. The climb is indicative of the excess power available for take-off. Landing distance is a function of stalling speed and per cent flap area. These curves are considered to be representative of liaison aircraft.

It has been determined from stall data on liaison aircraft that, with a well-designed wing and wing to body juncture, a maximum overall flaps-up lift coefficient of 1.6 can be expected. A plot (Fig. 7) of the ΔC_L that can be expected from flaps indicates that, with slotted flaps, spoilers, and small "feeler" ailerons, a value of 1.02 can be obtained, making the flaps-down lift coefficient equal to 2.62 at stall. This is not the wing C_L but the overall airplane lift coefficient with power off and represents the probable average—not the maximum attainable value with specialized flap design.

At this point, it is well to consider the effect of flaps on performance (see Fig. 8). The airplane in this example has a 37-ft. span, a weight of 1,980 lbs., a stalling speed of 40 m.p.h., and 125 hp. Thirty per cent flap area means a 40 per cent reduction in wing area over that of an unflapped airplane—an important size factor. Thirty per cent flap area means a rate of climb increase from 415 to 750 ft. per min., or 81 per cent; an increase in maximum speed from 75 to 112 m.p.h., or 50 per cent; a decrease in take-off distance from 1,000 to 550 ft., or 45 per cent; and a decrease in landing distance from

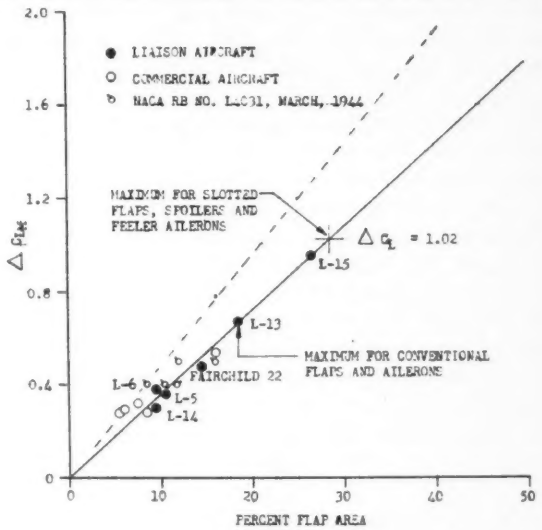


FIG. 7. Flap lift increment.

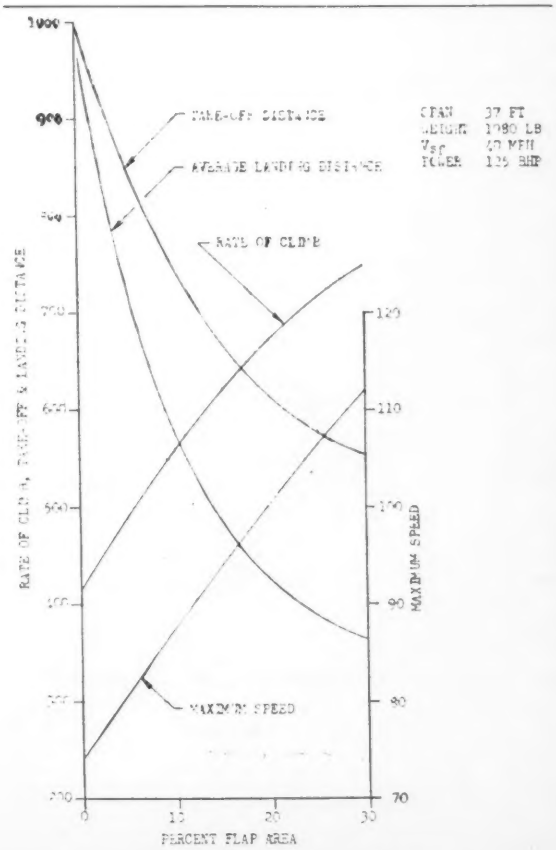


FIG. 8. Performance vs. flap area.

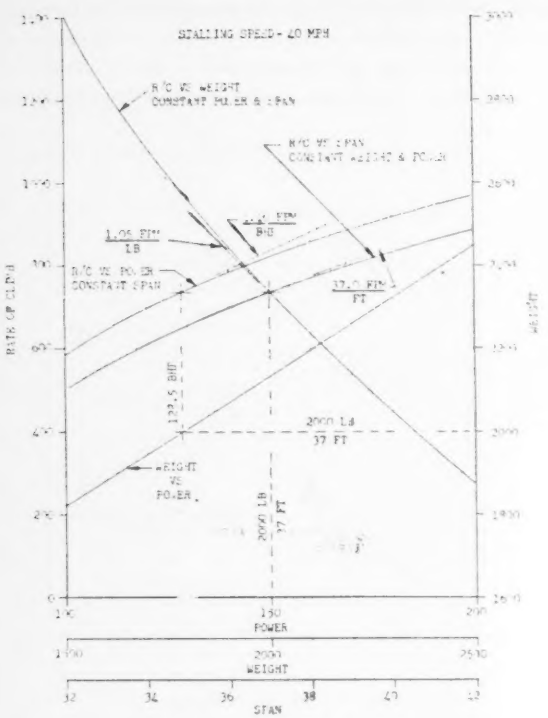


FIG. 9. Performance vs. span.

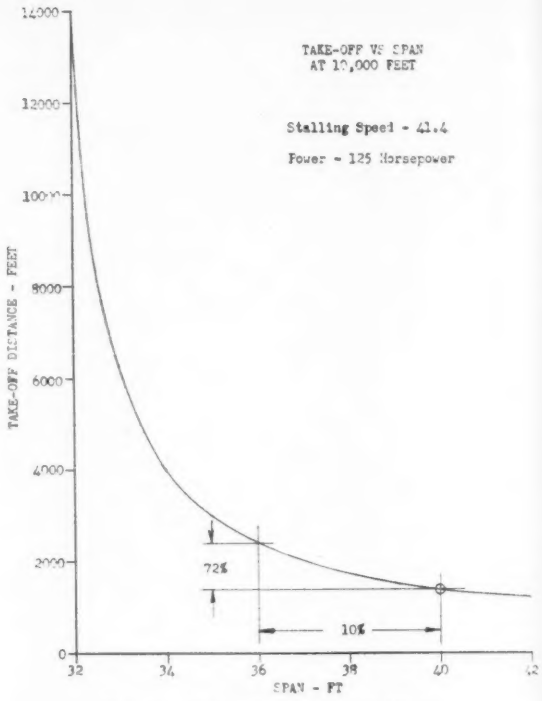


FIG. 11. Take-off vs. span—10,000 ft.

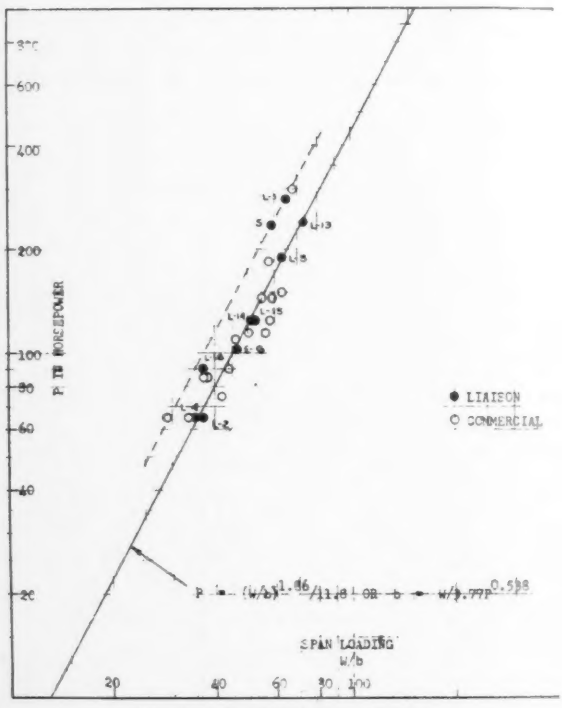
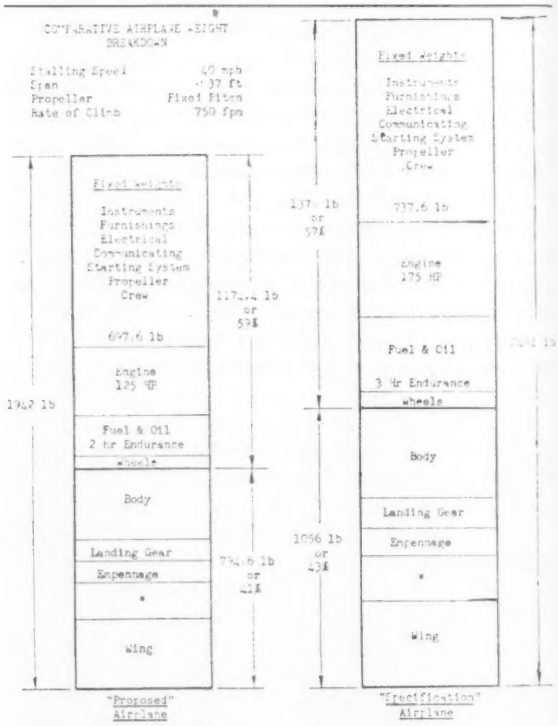


FIG. 10. Span loading vs. power.



*Fuel System; Engine Controls, Engine Section & Flight Controls

FIG. 12. Comparative airplane weight breakdown.

1,000 to 365 ft., or 63 per cent, over an unflapped airplane of this type. Obviously, the liaison airplane must carry maximum flap area.

Span is another important factor in light airplane design, as we have previously indicated. Data based on a 2,000-lb. airplane with a 37-ft. span, a 40 m.p.h. stalling speed, and 128.5 hp. (see Fig. 9) show that a 1-lb. weight change means a 1.05 ft. per min. change in climb, that a 1-hp. change in power means a 4.46 ft. per min. change in climb, while a 1-ft. change in span means a 37 ft. per min. change in climb. In this particular case, which is representative of liaison aircraft, a 1-ft. change in span is equivalent to a change of 8.3 hp. or a 35-lb. weight change. It follows that the 3-ft. reduction in span limitation will require a 25-hp. increase in power or a 105-lb. weight reduction. Another interesting relationship of span loading and power can be obtained by plotting span loading vs. rated power for existing light aircraft (Fig. 10). It will be noted that liaison airplanes, both military and off-the-shelf, follow a well-defined trend. According to this curve, a 125-hp., 2,000-lb. liaison airplane should have a 39.6-ft. span, which is in close agreement with the results of this study, as will be shown later. The most pronounced effect of span on performance is that on take-off at 10,000 ft. (see Fig. 11). Here, a 10 per cent span reduction from 40 to 36 ft. has resulted in a 72 per cent increase in take-off distance, and a 20 per cent reduction increases the take-off distance almost 900 per cent. Requirements for span reduction, therefore, warrant careful consideration, weighing the value of the reduction from a dimensional point of view against the performance penalty.

Discussion

The new liaison airplane type specification requires a weight allowance as part of the design load of 100 lbs. for communicating and miscellaneous equipment. The exact nature of the miscellaneous equipment is not known; however, it is suspected to be baggage, since the specification calls for all tactical equipment carried by liaison aircraft in combat. At any rate, the heaviest tactical radio equipment used in liaison aircraft weighs 57.3 lbs. A lighter weight tactical radio is now under development. It is therefore believed that the tactical value of the aircraft would not be impaired by reducing the design weight allowance to 60 lbs., with the additional 40 to be carried as overload when required. The new liaison airplane specification requires a minimum of 3 hours' endurance at not more than 75 per cent power. An endurance of 2 hours at full rich mixture, or 2.25 hours at best power mixture, at 75 per cent power will provide 5 to 6 hours' endurance at maximum economy mixture at operating speeds. It is therefore believed that the design fuel load should be reduced to 2 hours', with additional tank space being provided for 1 additional hours' fuel to be carried as overload when required for ferry purposes, etc. For the purpose of identification, these two aircraft will be designated as "specification" and "proposed" airplanes, one meeting the full specification requirements and the other incorporating the two deviations therefrom previously indicated.

The effect of these two deviations from requirements on weight is surprising (see Fig. 12). Here, we have two airplanes with the same span, stalling speed, and rate of climb. The "proposed" airplane has 125 hp. and weighs 1,942 lbs., while the "specification" airplane has a 175-hp. engine and weighs 2,431 lbs. Both airplanes have identical tactical equipment. It is obvious that the designer of the liaison airplane exercises limited control over only 41 to 43 per cent of the airplane weight, while, on the other hand, the type specification completely controls 57 to 59 per cent of the weight. In this example and for liaison airplanes in general, the addition of 1 lb. of fixed weight adds 1.81 lbs. to the airplane gross weight. The addition of a requirement for a directional gyro, artificial horizon with inverter, totaling 17 lbs., will increase the airplane weight 31 lbs. and reduce the climb 33 ft. per min. if power, stalling speed, and load factors remain constant. With constant endurance, load factors, and stalling speed, the addition of 1 hp. will add 6.35 lbs. to the airplane weight.

A plot of performance vs. stalling speed (Fig. 13) for the proposed airplane with a 37-ft. span and 125 hp. indicates that the optimum stalling speed, insofar as take-off is concerned, is 43.2 m.p.h. Contrary to what might off-hand be expected, the take-off distance does not continue to reduce with a reduction in stalling

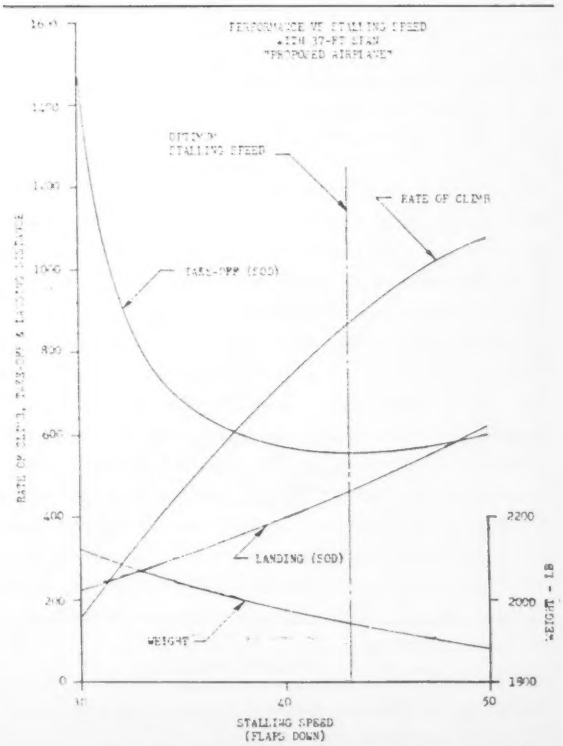


Fig. 13. Performance vs. stalling speed.

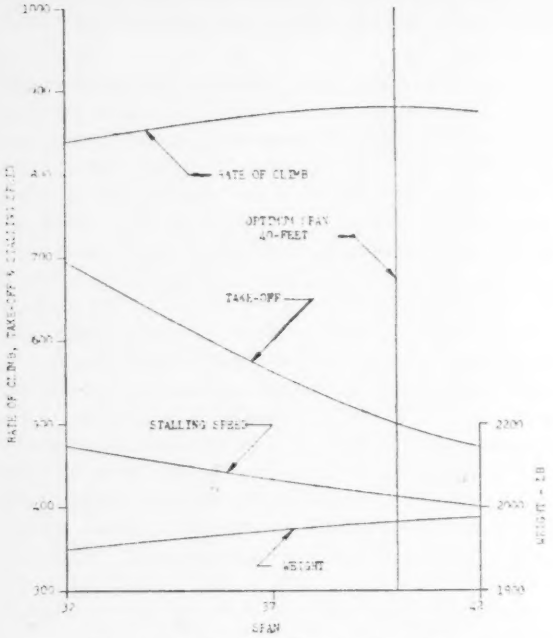


FIG. 14. Optimum stalling speed vs. span.

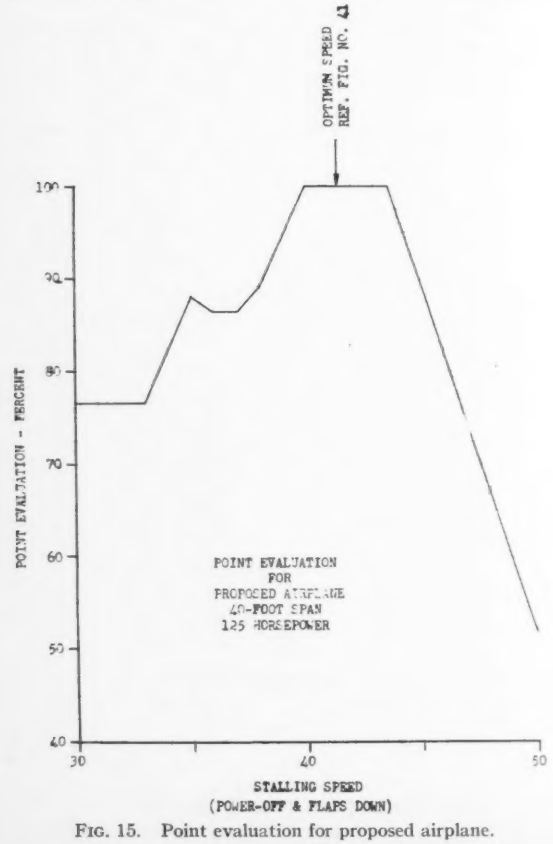


FIG. 15. Point evaluation for proposed airplane.

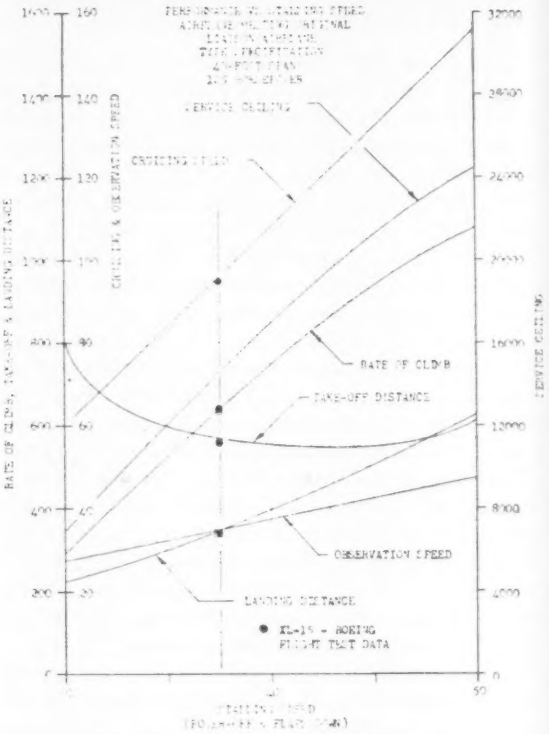


FIG. 16. Performance vs. stalling speed.

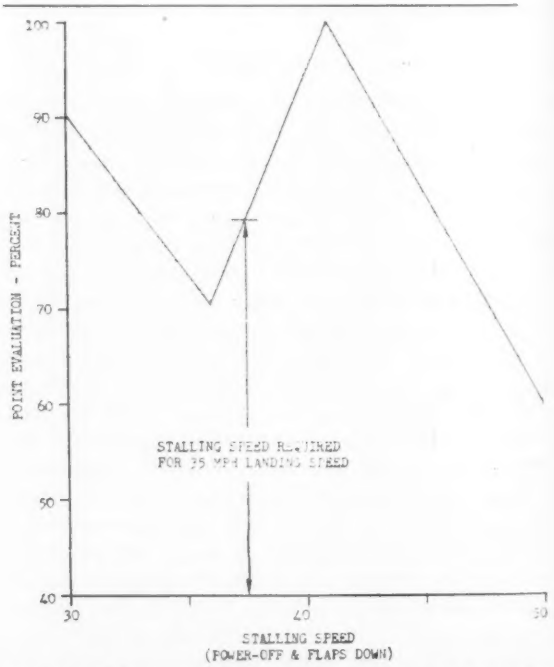


FIG. 17. Point evaluation for airplane meeting original liaison airplane type specification; 40-ft. span, 125 hp.

speed. After a series of such computations, it is possible to plot the performance at these optimum speeds vs. span. Fig. 14 shows that the optimum of these speeds for climb occurs with a span of 40 ft. and a stalling speed of 41.4 m.p.h. Let us now compare the performance of this "proposed" airplane with a "specification" airplane having the same stalling speed (Table 3).

TABLE 3
Performance

Item	Proposed Airplane	Specification Airplane	Difference
Power	125	220	+95
Span, ft.	40	37	−3
Weight, lbs.	1,960	2,730	+770
Maximum speed, m.p.h.	124	110	−14
Cruising speed, m.p.h.	110	98	−12
Service ceiling, ft.	20,000	14,500	−5,500
Rate of climb, ft. per min.	880	840	−40
Take-off distance, ft. (sea level)	500	525	+25
Take-off distance, ft. (10,000 ft.)	1,400	1,850	+450
Landing distance, ft.	425	425	0
Climb at 10,000 ft., ft. per min.	380	298	−82
Endurance—normal, hours	2	3	+1
Endurance—overload, hours	3	...	...

The specification airplane would have to be powered with a geared engine similar to the GO-435 and be equipped with a constant-speed wood propeller similar to that used on the L-13. The specification airplane is, in fact, approaching the size and performance of the L-13, which has 240 hp. and weighs 2,900 lbs. It should be remembered that the type specification stated that an airplane with a 1,000-lb. weight empty was desired. It will be noted that one further exception has been taken to the specification—the use of the optimum 40-ft. span. If the span is reduced to 37 ft., still retaining the same stalling speed, the performance compares as shown in Table 4. Obviously, development studies, together with practical consideration of design requirements, will pay off in smaller and more efficient aircraft. In this case, the 3-ft. span reduction resulted in a 90-ft. per min. reduction in climb, a 3,100-ft. reduction in service ceiling, and a 57-ft. increase in take-off distance.

TABLE 4
Performance

Span, ft.	37	40
Rate of climb, ft. per min.	790	880
Service ceiling, ft.	16,900	20,000
Take-off distance, ft.	557	500

It is interesting to now apply the point evaluation system (Fig. 15) for performance as used by the Air Materiel Command in the evaluation of the 1946 liaison airplane competition eliminating landing speed and substituting observation speed. It has been found that, for the 40-ft. span, 125-hp. proposed airplane, the maximum number of points are attained with a stalling speed range from 40 to 43.6 m.p.h., averaging 41.8 m.p.h. This figure is in close agreement with that previously determined. The next step is the application of this performance evaluation to an airplane meeting the requirements of the original type specification to which the XL-15 was designed. The airplane has 125 hp. and a fixed-pitch metal propeller. Fig. 16, showing the variation of performance with stalling speed, is interesting in that it shows close agreement with the XL-15 performance and that it again shows that the shortest take-off is not necessarily attained at the lowest stalling speed. The performance evaluation (see Fig. 17) shows that the maximum number of points is attained at a 41-m.p.h. stalling speed in spite of the high value assigned to landing speed—40 out of the possible 200 points. If the point system correctly reflects the relative importance of the various performance items, it can be assumed that the Army desired an airplane with approximately a 40-m.p.h. landing speed rather than the 35-m.p.h. maximum specified. This must be true, since the 35-m.p.h. landing speed requirement has now been deleted in favor of an observation-speed requirement. The cost of this one specification requirement on performance is great (see Table 5). This brings us back to the point previously mentioned that the military characteristics are to a large extent going to determine the final airplane performance.

TABLE 5
Performance

Landing speed, m.p.h.	35	40
Power-off stalling speed, m.p.h.	37.5	42.5
Rate of climb, ft. per min.	640	850
Service ceiling, ft.	14,700	19,200
Cruising speed, m.p.h.	95	119
Take-off distance, ft.	570	545
Landing distance, ft.	345	450

The possibility of further improvement in performance through the use of propeller speed reduction units is remote (Fig. 18). In the development of these data, 40 lbs. has been allowed for a belt drive. Wood blades in a constant-speed hub have been used, since metal blades would present a serious weight and availability problem in the larger diameters. An activity factor of 80 was used throughout and is probably low for the small diameters and high for the large diameters. The optimum diameter for climb and take-off is 104 in., with a reduction ratio of 0.67. There is no improvement in climb and take-off performance over that obtained with the direct-drive engine and metal propeller. This is partially due to the reduced efficiency of the wood propellers, to their restricted diameter to avoid tip speed losses, and to the increased weight due to the reduction drive and large propeller diameters. These calculations and resulting conclusions apply to liaison aircraft of approximately 2,000 lbs. weight and 125 hp. It is possible that improvements from gearing can be achieved on small and low-powered airplanes where the propeller size and weight is reasonable.

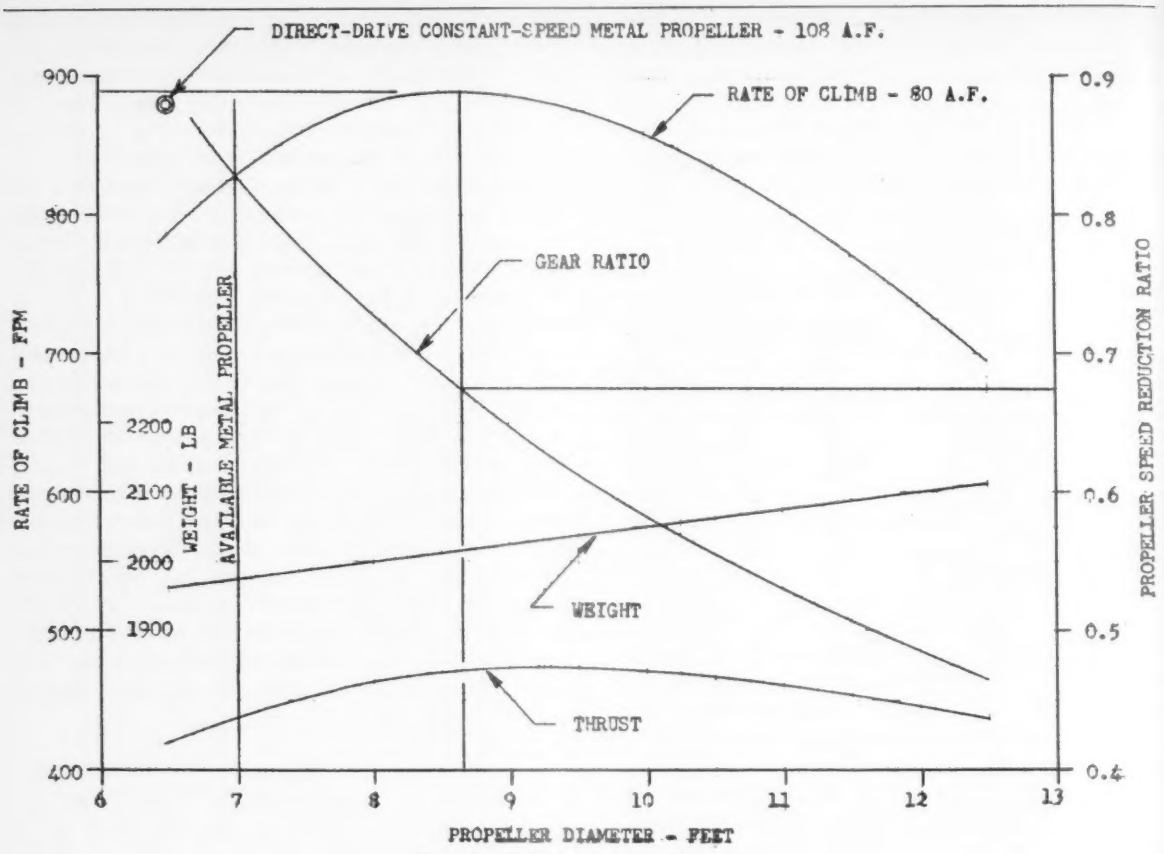


FIG. 18. Geared propeller performance.

CONTROL REQUIREMENTS

A $pb/2V$ of 0.07, with a minimum pb of 10 ft. per sec., does not appear to provide adequate control for liaison aircraft. The Army Field Forces have since modified their requirements to specify a minimum $pb/2V$ of 0.09; however, they failed to revise the minimum value of pb. Fig. 19 depicts the various Army, Air Force, and Navy requirements, together with some actual values on existing aircraft. Since the stalling speed of the liaison airplane will have to be around 40 m.p.h., it is obvious that little was gained through this particular change in requirements. The L-15, at an approach speed of 65 m.p.h. with flaps up, has satisfactory control characteristics in any reasonable weather condition. Other airplanes, such as the L-5 and L-6, appear to have good control. It is therefore believed that the original value of $pb/2V$ should be retained but that the minimum value of pb should be increased to 16 ft. per sec. This would mean that the L-15, for example, should actually have a $pb/2V$ of 0.14 rather than 0.08.

FLOTATION

Flotation is another serious problem with liaison aircraft, since they must operate from unprepared, plowed, muddy, and sandy fields. Tire pressure, and not wheel size as specified in the "military characteristics," should be the governing criteria. (See Fig. 20.)

The A.M.C. has established a tire pressure of 16 lbs. per sq.in. as a maximum limit for their liaison aircraft; however, this does not provide adequate flotation for sand. The L-15, with a tire pressure of 10 lbs. per sq.in., does appear satisfactory, since it has been operated from plowed sand areas. Army Ordnance recommends a maximum pressure of 12 lbs. per sq.in. for operation of motor vehicles on sand. It is therefore believed that 10 lbs. per sq.in. at 35 per cent deflection should be established as a limit for liaison aircraft. The tail wheel may have a considerably higher pressure. Without further data available, it can only be said that the 30 lbs. per sq.in. pressure in the tail-wheel tire on the L-15 may be a little on the high side.

FLIGHT TESTING

Accurate flight testing of light aircraft presents more of a problem than does that of large aircraft. Because of the short range of these aircraft, it is almost impossible to survey the area for vertical currents and to select the most suitable area, as can be done, for example, with the B-50. For the same reason and because of low ceilings, most test work on light aircraft is conducted at low altitudes, where atmospheric conditions are most erratic and variable. Obviously, flying near clouds or in rough or turbulent air will produce data that, at the best, can be considered only approx-

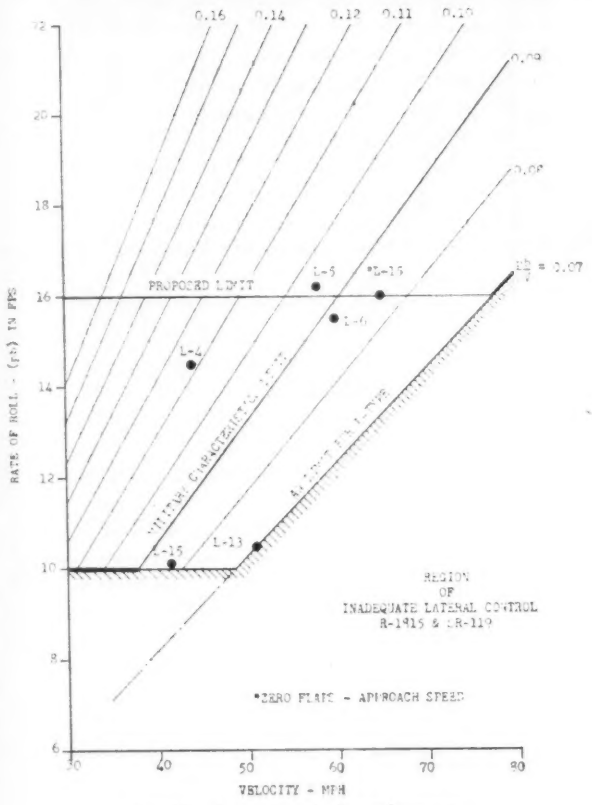


FIG. 19. Lateral control requirements.

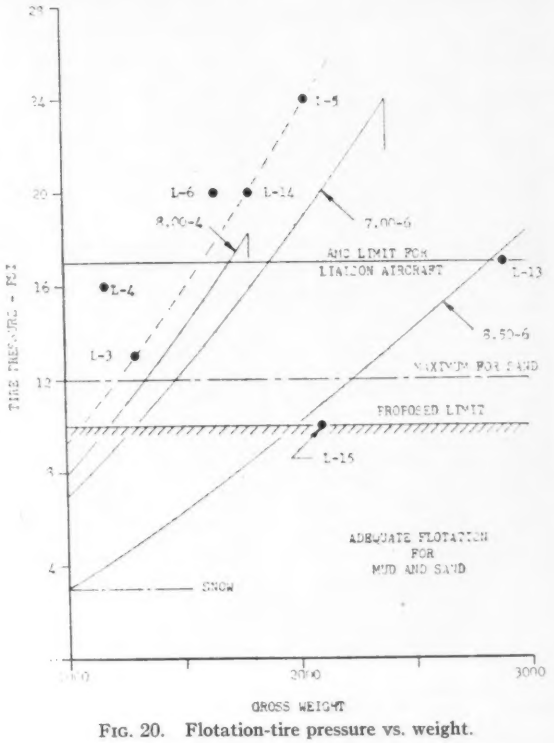


FIG. 20. Flotation-tire pressure vs. weight.

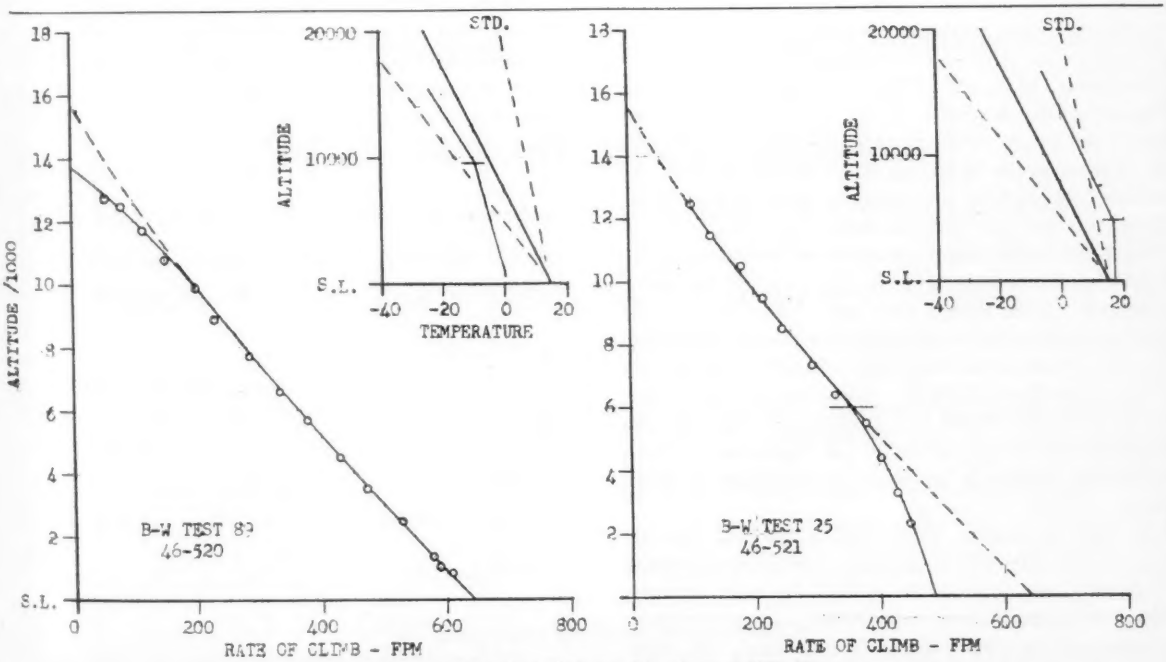


FIG. 21. Test rate of climb vs. altitude, model XL-15.

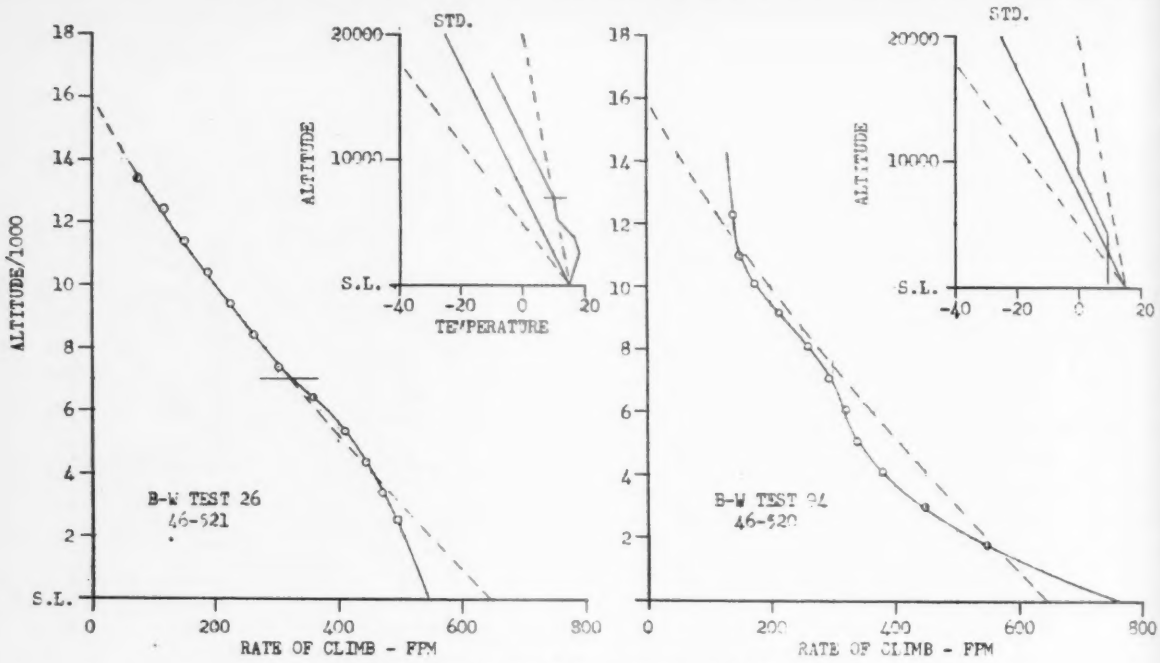


FIG. 22. Test rate of climb vs. altitude, model XL-15.

imate. Clear weather, free of clouds, such as is often experienced in the Wichita Area, appears ideal; however, more often than not it is unsatisfactory. The lapse rate or change of free air temperature with altitude has a pronounced effect on the determination of satisfactory or unsatisfactory conditions. Climb tests conducted when a standard lapse rate exists can normally be expected to be good, provided there are no breaks in the lapse-rate curve. The maximum variation from the standard of 2° per 1,000 ft., which can be expected to give reasonable results, is 1°C. per 1,000 ft.; in other words, lapse-rate curves of 3° per 1,000 or 1° per 1,000 ft. Breaks in the lapse-rate curve usually indicate the presence of vertical air currents and turbulent air. Data recorded near such changes will ordinarily be of little value. The effect on climb is pronounced (see Fig. 21). These tests on the XL-15 bring out this point very well. Note that in each case the break in climb and lapse rate occur at approximately the same altitude. Test No. 89 was satisfactory below 10,000 ft., while Test 25 was good above 6,000 ft. These curves coincide between 6,000 and 10,000 ft. Test No. 94 (Fig. 22) was unsatisfactory at all altitudes. A minimum of three continuous climbs is necessary to establish a climb curve.

It will be found that Diehl's general rate-of-climb curve (Fig. 23) is extremely useful in extending climb data and is accurate at least for light aircraft. Adequate instrumentation, including a photorecorder, is necessary for proper evaluation of data. In climb tests, it is particularly necessary to record photographically the instrument readings at frequent intervals to permit accurate plotting and analysis of the resulting data from the standpoint of atmospheric conditions. It is difficult to find room for such instrumentation in light aircraft, as shown by a photograph (Fig. 24) of the observer's cockpit in the XL-15. This instrumentation includes a fuel flowmeter, pressure-gage switches, potentiometer with multipoint switch, intervalometer for operation of the camera, a 35-mm. camera, and photorecorder box housing an altimeter, air-speed indicator, tachometer, manifold pressure gage, clock, and space for one additional instrument. It was necessary to use a helicopter air-speed indicator for the XL-15 tests.

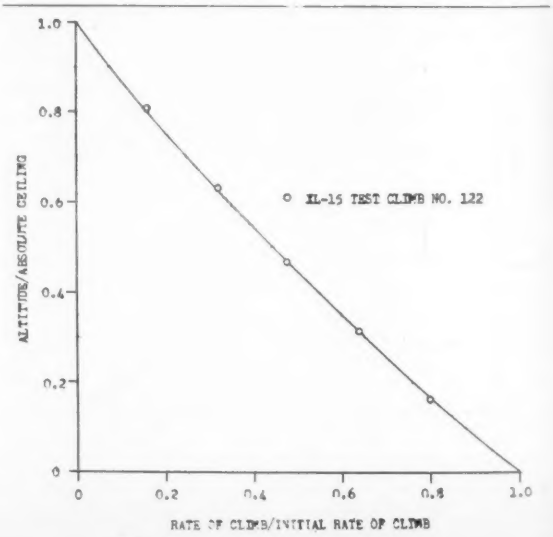


FIG. 23. General rate-of-climb curve.

Conclusions

It is not intended that the performance data presented herein should be interpreted as the maximum that can be achieved with extended study and research. These data are, however, comparative and indicative of the effect of changes in the various design factors. It has been assumed in each case that the example was specifically designed for the conditions set forth and not a modification of another version.

I believe that it can be safely said that the development of a light airplane presents far more problems than normally credited to it. Design and development studies are necessary if maximum performance is to be obtained at a minimum of power and airplane size. Further development work is necessary in light aircraft power plants, carburetion, propellers, flaps, and, particularly, in low-speed control. In the case of liaison aircraft, it is particularly important that more consideration be given to the consistency and practicability of type specification requirements. Development of the YL-15 has extended over a 4-year period. It took 1 year from the start of design to the initial flight. Such development work cannot be done when emergency conditions arise. In order to increase the utility and to improve the performance of liaison aircraft, the designer must depart from the conventional, which means coordinated and intelligent, as well as expensive, development work. This paper has been primarily limited to liaison aircraft for obvious reasons; however, it is hoped that some of the things learned in the XL-15 development and presented here will be of value to the light aircraft industry in general.

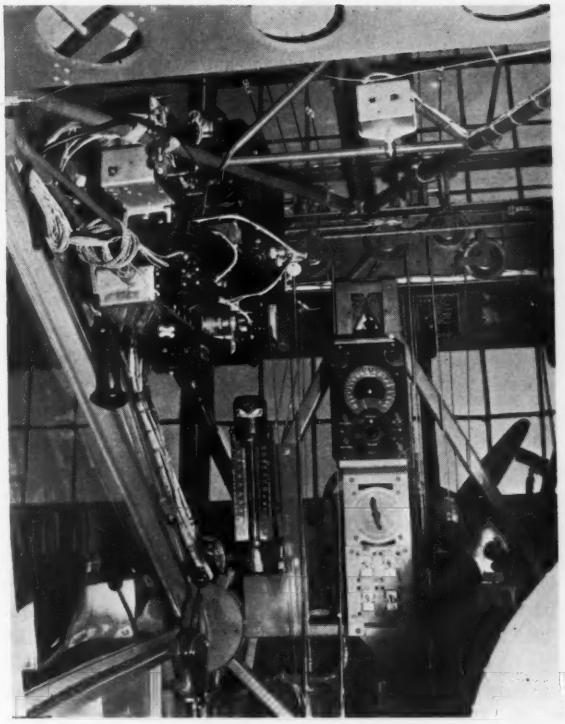


Fig. 24. Instrumentation photo, XL-15.

I.A.S. National Meeting Schedule

Annual Summer Meeting—Western Headquarters Building, Los Angeles—July 12–14

Wright Brothers Lecture—U. S. Chamber of Commerce Auditorium, Washington, D. C.—December 16

Nineteenth Annual Meeting—Hotel Astor, New York, January 29–31, February 1, 1951

Members or organizations wishing to submit papers for presentation at National Meetings should send outlines or summaries to the Committee no later than 5 months prior to the meeting.

All papers submitted will be considered for publication in the *Journal of the Aeronautical Sciences* or the *Aeronautical Engineering Review*.

All correspondence should be addressed to:

The Meetings Committee, Institute of the Aeronautical Sciences, 2 East 64th Street, New York 21, N.Y.

Do We Need Turboprops?*

E. V. FARRAR† and R. E. JOHNSON‡
Wright Aeronautical Corporation

THE FUNDAMENTAL CONSIDERATIONS involved in the question, "Do we need turboprops?" are no different from those of 20 years ago when we were all trying to decide between liquid- versus air-cooled power plants. However, the solution of the present-day power-plant selection problem is greatly complicated by the number of different types of power plants from which we may choose. Now we must consider the reciprocating engine, the turboprop, and the turbojet in all their numerous variations when we endeavor to choose a power plant for the next step in transport airplanes. In addition, we must recognize the potentialities of other types of power plants under development and be prepared to fit them into the future aircraft speed-range spectrum. The rocket, the ram-jet, and the atomic power plant are in this category and will undoubtedly be the subject of future discussions when turboprops and turbojets have demonstrated their proper field of usefulness as aircraft engines.

In view of the present state of development of the various types of engines just mentioned we have confined this analysis to the air-cooled radial reciprocating engine, the turboprop, and the turbojet. The factors of airplane range, airplane speed, and cost of operation with these engine types are examined as applicable to commercial transport airplanes.

As a first step in the analysis we have endeavored to eliminate all airplane factors and consider only the installed power plants in order to determine which type delivers the greatest percentage of fuel energy in the form of net thrust to an airplane. We believe Fig. 1 will help clarify the assumptions made in the first step of this analysis.

We assume that the power plant with its installation features is entirely divorced from any airplane and propels only itself with enough wing area for its own support. Wing area or tankage necessary to carry fuel is not considered because it varies so greatly with the type of airplane in which an engine may be installed. To keep our comparison of engines as simple as possible, we consider only nacelle-mounted power plants. With these assumptions we have endeavored to determine the maximum per cent of the energy in each pound of fuel burned which can be made available as net thrust from the several engine types after the engine has generated enough thrust to lift and propel itself at various aircraft speeds. Referring to Fig. 1, we propose to find the engine type that will give us the maximum per cent of the total energy of the fuel burned as pull on the towing cable. This we will do for speeds from 200 to 1,000 m.p.h. We believe that this is the simplest way to determine which engines are worthy of more complete consideration and that it will facilitate a better understanding of the overall problem that is, of course, to select an engine that, when installed in an aircraft, best performs a given mission.

We all know that only a relatively small per cent of the total fuel energy is available as net thrust, and, if we analyze the problem, we find that the total energy of the fuel is dissipated through the channels shown in Table 1.

The nature of these various losses should probably be enlarged upon as follows.

(*A*) *Unavailable Energy Inherent in the Basic Thermodynamic Cycle:* This is the loss that must be accepted in a thermodynamic cycle when heat is added to the working fluid, even though the successive steps of the cycle are assumed to be accomplished at 100 per cent efficiency. As we shall see later, this loss varies appreciably with the various types of engines and operating conditions.

(*B*) *Internal Losses:* These losses include all which exist, because the steps of the thermodynamic cycle are not actually performed at 100 per cent efficiency. They include friction; aerodynamic and thermodynamic losses in the gas passages; and, when we consider turboprop and turbojet engines, they also include losses in the compressor, combustion chamber, turbine, and jet nozzle.

TABLE 1

Fuel Energy Distribution for Air-Consuming Aircraft Engines

(A)	Unavailable energy inherent in the basic thermodynamic cycle.
(B)	Internal losses.
(C)	Propulsive losses.
(D)	Parasite drag loss of power plant.
(E)	Induced drag loss of power plant.
(F)	Useful propulsive energy.

Presented at the Fifth Annual Flight Propulsion Meeting I.A.S., Cleveland, March 24, 1950.

* We are indebted to the interest and foresight of W. G. Lundquist, Chief Engineer, Wright Aeronautical Corporation, and George Page, Chief Engineer, Curtiss-Wright Airplane Division, for the great mass of data that made this paper possible and deeply appreciate their permission to use it. Many engineers under the supervision of Messrs. Lundquist and Page contributed with what has been aptly termed "dog and sleigh work." We also appreciate permission of the I.A.S. to use certain data from a previous paper by Mr. Lundquist entitled "Optimum Fields of Application for Air-Consuming Power Plants."

† Assistant Chief Engineer.

‡ Sales Engineering Manager.

(*C*) *Propulsive Losses:* The propulsive device is considered a part of the power plant whether it is a propeller or a jet. This loss is that introduced by the propulsive device when transforming the mechanical energy output of the engine to thrust. Variation of propeller efficiency with aircraft speed is an important factor on those engines using propellers. The same efficiency values were used for propellers whether installed on turboprops or reciprocating engines.

(*D*) *Parasite Drag Loss of Power Plant:* All power plants were considered to be nacelle-mounted. This analysis does not cover the case of submerged engine installations. The nacelle drag loss was calculated as a function of the frontal area of the installed power plant and the wetted area of the nacelle.

(*E*) *Induced Drag Loss of Power Plant:* The value of this loss was established on the basis of an increase in the induced drag of an airplane introduced by the weight of the installed power plant, including a propeller when used. For the purposes of this comparison the L/D ratio at any aircraft speed was considered the same for an aircraft with any one of the three types of power plant. This may be subject to some criticism but fortunately does not have an important bearing on the conclusions reached.

(*F*) *Useful Propulsive Energy:* This represents the energy that is available for propulsion of the aircraft itself, since all the fuel energy required to propel the power plant has already been deducted. At any speed, the power plant that has greatest residual available energy as thrust is the power plant likely to be most suitable from the standpoint of maximum range at that speed.

Fig. 2 shows the energy utilization of a geared supercharged reciprocating engine at various air speeds at 20,000 ft. altitude. Perhaps the most important thing to note on Fig. 2 is that the ideal cycle loss does not vary perceptibly with aircraft speed. A question might be raised as to why the internal engine loss varies with aircraft speeds. The important factor here is that various engine r.p.m. may be utilized at the several aircraft speeds. In each case engine power was chosen to make the per cent of useful propulsive energy from the fuel used a maximum, and analysis indicates that up to 500 m.p.h. maximum per cent useful propulsive energy will result if a reciprocating engine is not operated at maximum r.p.m. The discontinuity in internal engine loss at 500 m.p.h. occurs because, above this speed, maximum per cent useful propulsive energy is obtained if the engine is operated at maximum power. There is no discontinuity in the curve of maximum per cent useful propulsive energy available. The dotted lines in the area of useful propulsive energy on either side of 500 m.p.h. show the effect of continuing above that speed at reduced engine power or below that speed at maximum engine power. It is clear from Fig. 2 that, as airplane speed is increased, internal engine losses, propulsive losses, nacelle drag losses, and induced drag losses consume a greater and greater per cent of the fuel energy until at approximately 625 m.p.h. the reciprocating engine can only fly itself and its installation features. Fig. 2 is based upon an engine having a specific fuel consumption of approximately 0.47 lb. per b.hp.-hr. at 60 per cent power in the high supercharger gear ratio.

Fig. 3 shows the energy distribution versus air speed at 35,000 ft. altitude for a turboprop engine of moder-

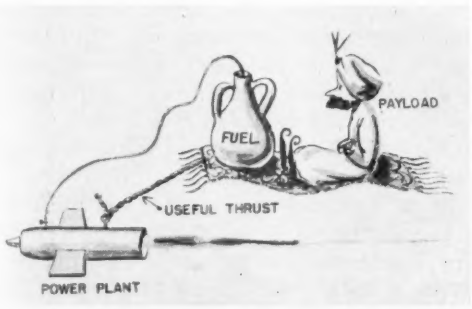


FIG. 1.

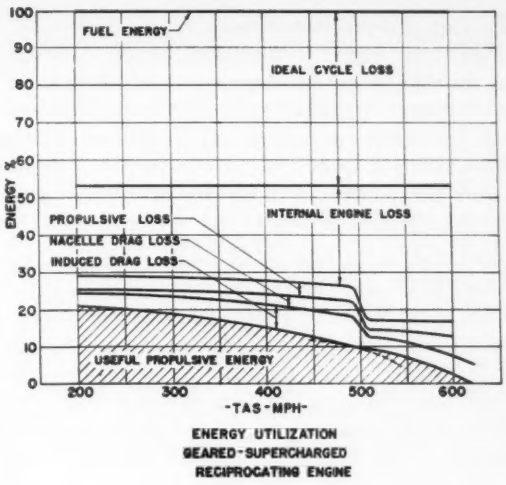


FIG. 2.

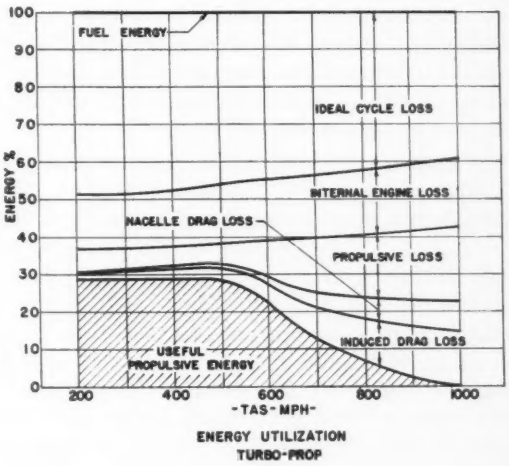


FIG. 3.

ately high internal compression ratio. Since this is, in a sense, an engine of the future, internal efficiencies that we believe will be obtained in 3 to 5 years were used. Important factors evaluated in this connection were: (A) inlet pressure loss, (B) compressor efficiency, (C) combustion efficiency, (D) combustion chamber pressure drop, (E) overall turbine efficiency, and (F) velocity coefficient of nozzle.

Note that, in the case of a turboprop, the ideal cycle loss becomes less as the air speed increases. This is true because the higher ram pressure effectively increases the overall compression ratio. This engine appears suitable for higher speeds than the reciprocating engine, because the ideal cycle loss does become less as aircraft speed increases and because the internal loss is less at all speeds. The effect of the propeller becomes very important at high speed, and, in spite of the favorable internal mechanism of the engine at an air speed of approximately 1,000 m.p.h., the engine is capable of flying only itself. Fig. 3 is based upon an engine with an equivalent specific fuel consumption of 0.48 lb. per b.hp.-hr. at 100 per cent power at static sea-level conditions. Approximately 11 per cent of the useful thrust is created by the exhaust jet.

Fig. 4 shows the energy distribution versus air speed at 35,000 ft. altitude for a turbojet engine of moderately high internal compression ratio. The same internal efficiencies were assumed as for the turboprop engine of Fig. 3. As in the case of the turboprop engine, ideal cycle losses decrease as air speed is increased. In the speed range shown, there is no important change in the internal engine losses. It is most important to note that propulsive losses also decrease as speed increases. This factor may be readily understood by reference to the expression for propulsive efficiency of a simple jet which is as follows:

$$e_p = 2/[(V_2/V_1) + 1]$$

where V_2 = jet velocity and V_1 = aircraft velocity. When applying this expression to a turbojet, it must be

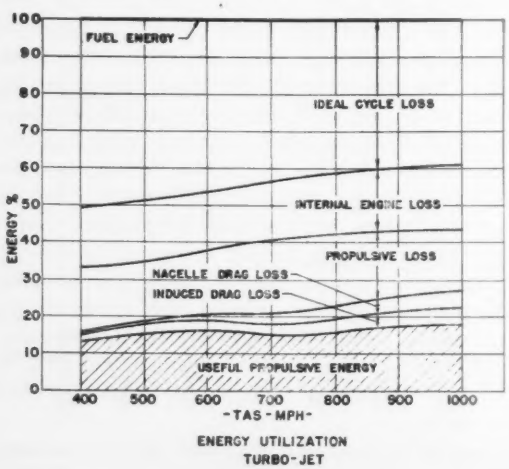


FIG. 4.

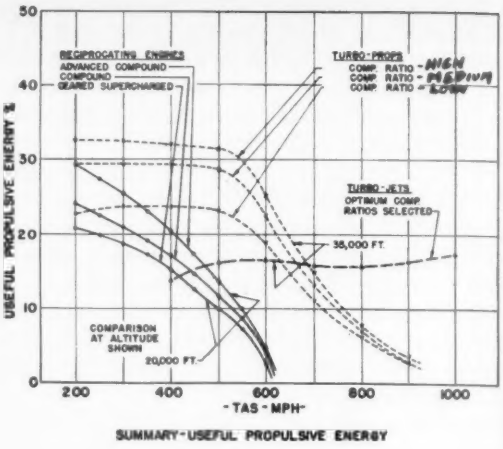


FIG. 5.

remembered that V_2 increases as V_1 is increased, but at a much lower rate.

Fig. 4 is based on a turbojet giving a sea-level static specific consumption of 0.77 lb. of fuel per hour per lb. of thrust at 70 per cent thrust and 0.95 lb. of fuel per hour per lb. of thrust at maximum thrust.

Analyses of the type just described were conducted on the following types of engines: (A) geared supercharged reciprocating engine; (B) compound reciprocating engine; (C) reciprocating engine with maximum compounding utilizing all possible exhaust energy for feedback to the propeller drive or for supercharging and with an intercooler between the supercharger and engine cylinders; (D) turbojets with low, medium, and high compression ratios, each at optimum fuel-air ratio; and (E) turboprops at low, medium, and high compression ratios each at maximum fuel-air ratio.

The results of these analyses are shown in Fig. 5. From this figure it appears that, at speeds between approximately 250 and 625 m.p.h., a turboprop engine is more economical of fuel than either a reciprocating engine or a turbojet. Propeller efficiency at the crossover point between turboprops and turbojets was taken as 71 per cent. It must be emphasized that these curves are based upon what might well be termed "rubber" engines, since each point is the best energy utilization that can be obtained at the assumed altitude and speed and does not represent one engine of the type in mind flying over a range of speeds or altitudes as it must in an airplane. We believe these curves are useful in that their construction has helped us understand the nature of the losses in various engine types; they show the speed ranges where a specific type is apt to be superior and the speed ranges where two types must be carefully considered in connection with an aircraft mission to determine which is superior.

Having considered the optimum fuel utilization of several engine types, let us now investigate our three power plants in terms of the cost of doing one specified job—that is, the transportation of 1 ton of goods, bombs, or people 1 mile. In this phase of our study, as in the previous one, it is difficult to segregate the engine-type

effects. It is necessary to design a whole series of airplanes to carry the specified package for various specified distances at different speeds and altitudes. All of these airplanes must have satisfactory take-off characteristics, be practical of construction, and meet the minimum performance standards of the C.A.A. Such an analysis has been made by the Airplane Division of Curtiss-Wright Corporation, in cooperation with the Propeller Division and Wright Aeronautical Corporation Division. This paper will show only the typical results of this study as applied to the question: "Do we need turboprops?"

Anyone familiar with the current C.A.A. cost analysis data knows that the vast amount of actual information collected during the past 15 or 20 years over millions of operating hours has given us accurate data on actual cost per revenue-mile, costs per ton-mile, etc., for various types and sizes of reciprocating engines. As far as the power plant is concerned, the essential items of cost are: (A) initial cost reflected in depreciation—engines and propellers; (B) parts replacement material cost—engines and propellers; (C) parts replacement labor cost—engines and propellers; (D) line maintenance parts and labor cost—engines and propellers; and (E) fuel and oil operating costs.

However, all items are much in doubt on the turboprop and turbojet. To analyze one or the other of these advanced types of power plants, we must "make up" our own figures.

Consider the first item—"depreciation—engines and propellers." In the United States, all turboprop and turbojet engine development has been carried on principally at the expense of the Government through military contracts. It has been carried on in facilities supplied directly or indirectly by the military, and these facilities, in general, cost two to three times as much as those required for the equivalent reciprocating engine. For example, a 4,000 b.hp. reciprocating engine takes a 4,000 b.hp. dynamometer, but a 4,000 b.hp. turboprop or equivalent turbojet requires a 12,000 b.hp. dynamometer or equivalent for component testing and development. In view of this, what is a true and fair initial cost to be used for the three types? For the purpose of this study we assume that a turbojet costs twice as much per pound as a reciprocating engine and that a turboprop exclusive of the propeller costs one and one-half times as much.

In the case of parts replacement material cost per overhaul, we know the figure for existing reciprocating engines very well but have little reliable information to use in connection with the other two types. In this study, we discounted what we believe to be present costs for turbojets and assumed that parts replacement cost per overhaul will be comparable with existing reciprocating engine experience. The time between overhauls was assumed to be one-third to one-half of that obtained by domestic air lines using reciprocating engines in the U.S.A. today. This is believed favorable to the turbojet and turboprop alike as they may exist 3 to 5 years from now in comparison with the reciprocating engine.

The third item of engine cost is the parts replacement and repair labor. Here, we find a wide variation of accounting practice in existence among domestic airline operators. For the purpose of this study, the basic engine and propeller overhaul labor was used. This item is relatively low on all three engine types, and the actual difference between reciprocating engines and turbine types will depend largely upon the type of compressor and details of the blade attachment. It is anticipated that the man-hours per overhaul for the turbine types may vary as much as ±25 per cent because of this factor. For this study, the three types were assumed to require the same man-hours per overhaul.

Line maintenance parts and labor cost for engines and propellers was assumed to be the same for all engines. The exact value of these items makes little difference in the total, since they are relatively small.

That brings us to the fuel and oil cost item. The cost of this one item overshadows all other effects for the various power plants for two reasons. There is a possible difference in cost per gallon and a calculable difference in the quantity required to perform the design objective—that is, transport a given pay load a given distance in a certified airplane and meet civil air transport requirements. It has been customary to assume that the reciprocating engine would use high-octane aviation gasoline of the 115/145 grade in comparison with kerosene or equivalent for the turboprop or jet engine. It has been popular for the proponents of the turbine-type engine to assume a 5-cent-per-gal. price advantage for this engine type. With all due apologies to the fuel producers, we doubt that there will be much actual difference between the two types of fuel if gasoline quantity decreases and the jet fuel quantity increases materially. This study was made with and without the 5-cent-per-gal. price differential.

Cost variables just discussed were applied to the following engines in appropriate airplanes of our series by using the A.T.A. cost formula: (A) geared supercharged reciprocating engine; (B) turbosupercharged reciprocating engine; (C) compound reciprocating engine; (D) turboprop, medium compression ratio; and (E) turbojet, medium compression ratio. Fuel consumption used for the turbine-type engines was based on what we believe reasonable at the end of 3 to 5 years' development and is therefore somewhat optimistic by present-day standards. The comparison was made only for ranges over 1,000 miles. The cost-per-ton-mile data shown on Fig. 6 are the result of the above-mentioned calculation. You will note that the general pattern is similar to that of Fig. 4 and indicates an optimum speed range for each type of power plant.

At any chosen speed, the airplane range that must be covered will not greatly affect the choice of engines. At the "crossover" points, either of two engines can do the job. Below 1,000 miles trip length, the costs with

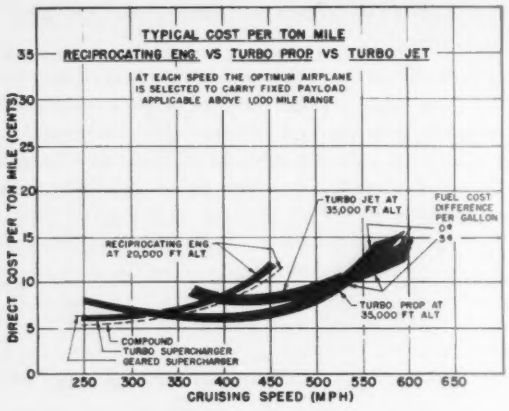

TYPICAL COST PER TON MILE
RECIPROCATING ENG. VS TURBO PROP VS TURBO JET
AT EACH SPEED THE OPTIMUM AIRPLANE IS SELECTED TO CARRY FIXED PAYLOAD APPLICABLE ABOVE 1,000 MILE RANGE
DIRECT COST PER TON MILE (CENTS)
CRUISING SPEED (MPH)
TURBO JET AT 35,000 FT. ALT.
FUEL COST DIFFERENCE PER GALLON
.09
.50
RECIPROCATING ENG AT 20,000 FT ALT
TURBO PROP AT 35,000 FT ALT
COMPOUND
TURBO SUPERCHARGER
GEARED SUPERCHARGER

FIG. 6.

turboprop- or turbojet-powered aircraft get higher relative to reciprocating engine-powered aircraft because of the increased percentage of flight time spent at low altitude.

The data for reciprocating engines are based on gasoline only, and the spread in costs is a function of the engine configuration. The spread in cost for turboprops and turbojets is a function of fuel cost, as indicated, and shows the large effect of the per gallon fuel cost variable.

Let us look at minimum ton-mile cost if we assume the same cost per gallon for gasoline or jet fuel. The geared supercharged reciprocating engine-powered airplane and the turboprop-powered airplane show about the same ton-mile cost, while the jet-powered airplane shows about 25 per cent higher ton-mile cost. The speeds for these three minimum costs are about 250, 400, and 450 m.p.h., respectively. Looked at another way, the turboprop airplane can fly 100 m.p.h. faster than a reciprocating-engined airplane at the same cost. It can fly at less cost than a turbojet airplane up to about 500 m.p.h. It is of interest to note that the compound reciprocating engine will fly at lower ton-mile cost than the turboprop up to 330 m.p.h., even if we assume the advantage of low cost fuel for the turboprop.

It is obvious that the airplane cost curves of Fig. 6 do not appear so favorable to the turboprop at low air speeds as do the energy utilization curves of Fig. 5. This is true because the turboprop- or turbojet-powered airplane must carry a relatively high fuel reserve to cover possible low-altitude or "holding" flight time.

Before trying to draw conclusions, there are a number of practical operating and design problems that must be resolved. Many of these problems do not lend themselves to analytical solution but, nevertheless, will influence any decision. Some of these practical considerations are as follows:

(A) The turboprop and turbojet will lose two to three times more take-off power than a reciprocating engine in going from a 60° to a 100° day, which may require special handling or reduced pay load with these engines.

(B) Large loss of pay load which accompanies any low-altitude flying required by weather, wind, turbulence, or loss of cabin pressurization may be important. This is caused by the high fuel consumption of the turboprop or turbojet at low or intermediate altitudes.

(C) How to protect the turbojet and turboprop from ice under all conditions has not been demonstrated. It took us 15 years to solve this problem in all its details with reciprocating engines, which have relatively low air consumption.

(D) The problem of stopping a turbojet-powered airplane under wet or icy runway conditions has not yet been solved.

(E) The practical problem of keeping daily airplane utilization up with the higher speed aircraft because of fixed passenger desires, such as no scheduled arrivals at 3:00 a.m., is a difficult one. It took 10 years for the U.S. domestic air lines to increase the daily utilization of the DC-3 from 5 to 10 hours per day. The DC-6's and Constellations have not made it in the 5 years since the war.

(F) There are some difficult problems in traffic control for extremely high-speed airplanes with which we are all reasonably familiar but the solution for which is not yet known.

Let us now summarize the facts as we understand them at this time, remembering that we have confined our cost analysis to airplanes operating at more than a 1,000-mile range.

(A) The turboprop-powered airplane will provide the lowest ton-mile cost from 350 to 500 m.p.h.

(B) The turboprop-powered airplane will fly 100 m.p.h. faster than a reciprocating engine-powered airplane for the same cost per ton-mile.

(C) The compound reciprocating engine provides the lowest cost per ton-mile below about 350 m.p.h.

(D) The minimum ton-mile cost of flying with a turbojet is approximately 30 per cent greater than the minimum ton-mile cost with a turboprop.

(E) The ton-mile cost of flying 600 m.p.h. with a turbojet is about two times the cost of flying 400 m.p.h. with a turboprop.

(F) The turbojet is in a more advanced state of development at this time than the turboprop. Both types will incur enormous development cost before they reach the stage assumed for this analysis.

We conclude:

(A) If we had turboprops today we would use them. Operational problems would be solved.

(B) From the commercial air transport point of view we believe we need turboprops. However, we are unwilling to hazard a guess as to whether or not the commercial advantage warrants the rather large cost of development in the next few years.

(C) We feel that the turboprop will reach full development after the turbojet unless military requirements make it advisable for the Services to support turboprop development more fully than seems probable at this time

Technical Sessions at Wichita

(*Continued from page 17*)

The second part of the paper dealt with the effect of the military-type specifications upon the final airplane. This portion of the paper is published in full on pages 18–29 in this issue.

A new and extremely interesting development was discussed by Fred Weick, Director, Personal Aircraft Research Center, Agricultural and Mechanical College of Texas. Mr. Weick, who is in charge of the design and construction of an agricultural dusting and spraying airplane, described the specifications his group has set up as a result of a survey of the operators of this type of equipment. These specifications were discussed from the standpoint of loads, performance, flying qualities, field of vision, protection of pilot, maintenance repair, and other factors.

The summary of these items indicates that between 800 to 1,200 lbs. of pay load are desirable with ranges from 400 to 2,000 lbs. indicated by the survey. The necessity for the use of both liquids and dusting materials emphasizes the problem of providing quick interchangeability between the two for the installation of both spraying and dusting systems.

Performance, particularly from soft and small fields, was emphasized. Speeds were low from the standpoint of ordinary aircraft, ranging from 60 to 90 m.p.h. for actual spraying and dusting operations, to 100 m.p.h. for cross-country cruise.

Emphasis was placed upon handling and flying qualities. The necessity of avoiding fatigue for pilots who operated for a full day made essential the extremely light controls and adequate control response. A point that would ordinarily be somewhat neglected was the installation of night-flying equipment because of the necessity of many operators flying to a job before daylight and returning from a job after dark.

Emphasis was placed upon the necessity for an adequate field of vision. The logical conclusion of this specification was a pilot placed high above the fuselage of a low-wing airplane, with visibility in all directions provided by an open cockpit. An adjustable seat is necessary to enable the pilot to adjust his height to that necessary to furnish adequate vision and yet permit him to operate the airplane on cross-country conditions.

The results of the Cornell Aeronautical Laboratory's crash research program were being utilized in the protection of the pilot. Forty *g* seats were being installed, together with seat belt and shoulder harness of the inertia-locking type. The structure was being designed with consideration given to progressive failure so that the major inertia and energy of the impact would be absorbed before the structure about the pilot was subjected to high loads. Discussion of the necessity for protecting the pilot from danger when inadvertently flying through trees and wires was cited. A sharpened edge on the spring-steel landing gear, together with guards that would deflect wires over the pilots head, was cited as a necessity because of the inherent inability of the pilot always to dodge such obstacles. In many cases, the ability of Mr. Weick to reduce the description of such actions to a methodical specifications language was fully appreciated by the group.

Great emphasis was being placed upon the properties of ease of maintenance and repair. While some serious consideration had been given to the use of fabric covering and steel tube fuselage because of the ability of even the smallest operators to perform repairs, it is felt that the increase in facilities for performing repairs, together with the many advantages of improved weathering ability and increased accessibility for cleaning, made the all-metal construction much more desirable. Since the materials used in spraying and dusting are in some cases highly corrosive, adequate protection against corrosion must be provided, and provisions for proper and complete cleaning must be made. The use of fuel cells to contain spraying chemicals, as well as painting and coverings of Vinyl plastic, was cited as a method to eliminate and avoid excessive corrosion. All in all, considerable effort was being expended to produce an airplane that would be easy to maintain and which could be depended upon to provide the greatest number of flying hours in the operating season.

The audience could not help but speculate as to the appearance of an aircraft design to meet these specifications. The hints of actual design configuration that were presented made it possible to sketch a somewhat dim mental view. The low-wing configuration, spring-steel gear, flat engine, single cockpit placed high above the fuselage, together with a wing of 21 per cent thick section, presented an airplane that obviously could not be said to be beautiful. However, if all specifications were satisfactorily met, it could be said that "beauty is only skin deep."

The showing of two films during the program were of considerable interest to the group. One was a training film on *Army Light Aviation* which adequately described the uses to which the ground forces are putting the light and liaison-type aircraft. The other was a film produced by the Shell Oil Company, Inc., on *British Aircraft Review 1949*. Also of interest to the group was the presence, at the Municipal Airport, of a de Havilland Dove flown by air attachés of the British embassy from Washington. Members of the group inspected this aircraft, and all were unanimous in their admiration for its competent design and trim external appearance. Comments were heard upon the availability of three-bladed controllable propellers for the size of engines used and the value that such equipment might find in this country.

Thus ended the Seventh Annual Personal Aircraft Meeting on its theme of work, progress, and research. Hope was expressed that, within the coming year, new developments would add further to the field of personal aircraft.

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I.A.S. Previews

Summaries of Current Papers Accepted for I.A.S. Publications

Hydrodynamic Longitudinal Stability

By

George S. Schairer
Boeing Airplane Company

The various forms of hydrodynamic instability of flying boats are described. The physical phenomena associated with these instabilities are examined. It is shown that there is a discontinuity in flow characteristics when the chine at the main step becomes submerged which changes the wetted area from a triangle to a trapezoid. In cases where the afterbody or tail extensions are not in water, this point of changing flow defines the lower porpoising limit. The lower limit is also partially determined by the point at which the afterbody first contacts the water. A form of upper limit porpoising which differs from skipping and closely resembles lower limiting porpoising is described. It is pointed out that hydrostabilizers can materially change lower-limit porpoising.

The Influence of Design Parameters on the Performance of Subsonic Air Inlets

By

Howard E. Roberts and B. D. Langtry
Douglas Aircraft Company, Inc.

This paper presents the results of an experimental investigation into the influence of design parameters on the performance of a certain class of subsonic air inlet. This class of inlet, normally located in the skin of the air frame, employs a boundary-layer bleed.

The influence of aspect ratio, degree of protuberance, ramp profile, boundary-layer thickness, and bleed position upon the inlet-total-pressure recovery, critical Mach Number, and boundary-layer-bleed-total-pressure recovery was determined. The results are summarized in the form of graphs and design charts that can be used by air-frame designers in the selection and design of air inlets that satisfy their requirements.

The application of these results to practical design problems is discussed.

Torsion of Thin-Walled Closed Cylinders Beyond the Elastic Limit

By

G. H. Handelman
Carnegie Institute of Technology

The torsion of thin-walled closed cylinders beyond the elastic limit is treated as a problem in "technical plasticity." From assumptions on the nature of the wall thickness, the problem is reduced to one of a single stress and a single strain. Formulas for the distribution of the shear stress, the shear strain, and the warping function are found. An analog to the formula for the torque vs. angle of twist in the elastic state is developed. It is shown how the problem may be reduced to an equivalent elastic tube through the introduction of an artificial thickness function. Formulas are also given for multicell sections. Specific numerical-graphical procedures are developed for sections of piecewise-constant wall thickness, and two examples, single-cell and multicell, are given in detail.

On the Stresses and Deflections in a Series of Cantilever Swept Plates of Uniform Thickness

By

E. E. Sechler, M. L. Williams, and Y. C. Fung
California Institute of Technology

For the past $2^1/_2$ years, under the sponsorship of the Air Materiel Command of the U. S. Air Force, GALCIT has been investigating the subject of the stresses in thin swept wings. The investigation has utilized theoretical, experimental, and electrical agencies on this problem. The problem has been reduced to a form amenable to theoretical analysis by assuming the wing replaced by a thin cantilever plate of uniform thickness.

A theoretical solution of a thin cantilever plate of rectangular cross section with varying angle of sweep has been obtained. Expansion of the deflection in terms of the normal modes of vibrating bars is employed, the coefficients being determined by the Rayleigh-Ritz method.

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See page 38 for Preprints that are immediately available.

Experimental data for both stress and deflection are also presented. An approximate solution yielding the qualitative behavior of the stresses in such plates is included.

The equations and circuits for the use of the electrical analog type of solution of plate problems are indicated, and a comparison is made between theoretical, experimental, and analog data, the latter being obtained by the use of a twelve-point electrical network.

Characteristics of the Turbulent Boundary Layer on a Flat Plate in Compressible Flow from Measurements of Friction in Pipes

By

Hans Ulrich Eckert
Air Materiel Command

With the development of high-speed aerodynamics, the influence of compressibility on the boundary layer becomes of growing importance. In the case of laminar flow, this influence has been treated in numerous papers, while for the turbulent boundary layer, which is less convenient to treat analytically, the literature is rather scarce. From the practical standpoint, however, the latter is in all probability the more important, since the transonic and supersonic velocities achieved at the present time are, in general, connected with Reynolds Numbers that, according to experience with incompressible flow, should lie well in the turbulent range. In cases of extremely high supersonic speeds only, since they will be restricted to gases of low density, Reynolds Numbers will be low enough so that extensive laminar boundary layers can be expected. Hence, extensive turbulent boundary layers will mainly occur in the

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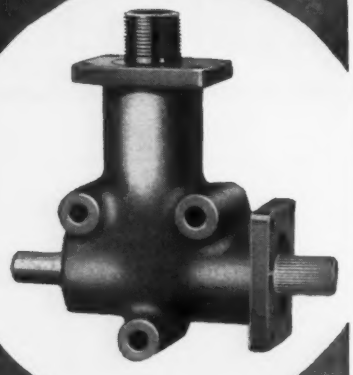

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low and medium Mach Number ranges. Therefore, it seems to be worth while to approach the problem by starting with formulas for incompressible flow and to allow for the heat due to friction by introducing simplified thermodynamic relations. Attempts of this kind have been made by von Kármán, Frankl, and Tetervin. They require, however, certain arbitrary assumptions regarding appropriate values for density and viscosity (values at the wall surface, in the free stream, or some mean values) which can be established only by experiments. The present paper attempts to eliminate the arbitrary character by applying the results of tests in pipes to the plate problem by a method analogous to that used first for the incompressible case by Prandtl and von Kármán.

The Gyroscopic Effect of a Rigid Rotating Propeller on Engine and Wing Vibration Modes

By

R. H. Scanlan and John C. Truman

Rensselaer Polytechnic Institute

In many wing vibration analyses it is found necessary to take into account the effect of flexibly mounted engines. Hence, it is reasonable to ask what vibratory gyroscopic effect this flexibility may give rise to when propellers are whirling. An engine mount may be thought of as a horizontal beam cantilevered from the wing, having both horizontal and vertical flexibility. If this beam were infinitely rigid horizontally, then, when it vibrated, the gyroscopic moments induced in the propeller due to the resultant pitching motion of its axis would not produce propeller axis yaw. However, engine mount lateral stiffness (which allows propeller axis yaw) may actually be less than vertical stiffness so that gyroscopic effects will play a role as the propeller axis undergoes pitching vibrations at the tip of the cantilever engine mount. The purpose of this paper is to investigate this role under the assumption that the propeller itself is a rigid disc.

The paper is divided into four parts. Part I deals briefly with classical gyroscope theory. Part II presents engine vibration mode studies—experimental photographic techniques on a model gyroscope mounted at the ends of two different cantilever beams. Part III presents the theory of the coupled motion of an elastic wing upon which a gyroscope is mounted to simulate an engine-propeller system on an airplane. Part IV consists of an example of the theory of Part III in which, by taking what are thought to be reasonable parameters, results are obtained showing how the whirling of a rigid propeller may materially affect wing normal mode shapes and frequencies.

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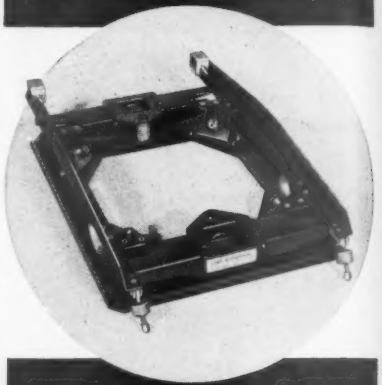

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A Mechanical Analogy for Hypersonic Flow

By

H. Reese Ivey

Langley Aeronautical Laboratory, N.A.C.A.

A mechanical analogy for hypersonic flow is described which may be useful for the Mach Number range of 5 to infinity.

The basic characteristics of the various flow types are reviewed: gas dynamics, slip flow, and free molecule flow. From that discussion the requirements are determined for an analogy to simulate hypersonic flows. The theory of the analogy is developed, and a simple apparatus is described for demonstrating it. The functions of the various parts of the device are explained, and typical photographs of the resulting flow are presented. The pictures show the gradual degeneration of shock waves as the effective operating altitude is increased from the gas dynamics region to the free molecule region. Possible uses of the analogy are suggested, and the operating limitations are discussed.

A System for the Excitation of Pure Natural Modes of Complex Structure

By

Robert C. Lewis and Donald L. Wrisley

Massachusetts Institute of Technology

Analogy is drawn between analytical and experimental approaches to the evaluation of structural dynamic behavior, pointing out the relationship between method complexity and adequacy of results.

The theory, construction, and operation of a system using 24 shakers controlled from a console in the systematic excitation of pure natural modes are described. Practical operation is made feasible by the coordinated display of the force and resultant velocity at each shaker station, together with a system for orderly, discriminatory adjustment by the operator, which is analogous to a mathematical iteration. Sample laboratory and full-scale data are shown.

The Hot-Wire Anemometer in Supersonic Flow

By

Leslie S. G. Kovasznay

The Johns Hopkins University

The hot-wire anemometer has proved to be a most valuable tool for turbulence research in the low-speed range. As interest grows in the problem of turbulence at supersonic velocities, it would appear natural to see whether the hot-wire anemometer could not also be used at higher speeds. However, a number of fundamental problems must be solved before the hot-wire can be considered as a successful instrument in the supersonic laboratory.

The first problem to be solved is that of obtaining adequate frequency response of the hot-wire equipment in order to resolve the turbulent fluctuations in space which are swept by the wire at high velocity in a supersonic flow. Encouraging progress has been made in using extremely fine wires and in developing electronic equipment that will compensate for the thermal lag of the wire at very high frequencies without interference from noise.

As yet, there is only a small amount of information available that can be used to predict the response of a hot-wire anemometer at such speeds. Because of the great difficulties of the theory of real compressible flows, most of the data will have to be obtained experimentally. The author has conducted systematic experiments to determine the law governing the heat loss from a hot-wire in a supersonic flow up to Mach Numbers of 2.0. It was found that the heat loss, expressed in the form of a Nusselt Number, is a unique function of the square root of the Reynolds Number when free-stream velocity and density are used and the viscosity and conductivity corresponds to stagnation conditions. This law is valid only in the case of small temperature loadings. For large temperature differences, a nonlinearity appears in sharp contrast to King's law which has been found to be linear with temperature difference over a wide range of temperature loadings.

The third problem that has been encountered is that of interpreting the hot-wire fluctuations when the number of flow parameters is large. Velocity, density, and temperature all contribute to the hot-wire reading, and it is believed that in some cases these effects may be separated. When the velocity field is a low-intensity turbulence (not random sound waves), the separation of measured fluctuations is accomplished.

A Recurrence Matrix Solution for the Dynamic Response of Elastic Aircraft

By

John C. Houbolt

Langley Aeronautical Laboratory, N.A.C.A.

A systematic procedure is developed for the calculation of the structural response of an airplane subject to dynamic loads. Particular attention is given to the problem of determining the stresses developed because of flight through gusts. Difference equivalents for derivatives and matrix notation are used to develop a recurrence relation that permits step-by-step calculation of the response and of the loads that occur on the structure. The chief feature of this recurrence approach is that the generality and physical aspects of the basic equilibrium relations of the problem are preserved without loss of ease in application.

The use of difference equivalents for derivatives in the solution of dynamic problems is first illustrated by means of a simple damped oscillator example, and the application of the flexible aircraft structure is then made. For brevity, the case of wing bending and vertical motion of the airplane is treated, although the method may be readily extended to take into account also wing torsional deformations, pitching motion of the airplane, fuselage deflections, and tail forces of known character. Either a sharp-edge gust or a gust of arbitrary shape in the spanwise or flight directions may be treated.

Some results obtained by application of the recurrence matrix relation are presented, and the advantages of this method over other methods of evaluating the dynamic response of an aircraft are discussed.

A Type of Lifting Rotor with Inherent Stability

By

Kurt Hohenemser

McDonnell Aircraft Corporation

The more important of the forward flight aerodynamic characteristics of a rotor type are presented where the collective blade pitch angle is kinematically coupled with the collective flapping or coning angle, while no coupling is provided between cyclic flapping and cyclic pitch angles. The rotor with pitch-cone change may be designed to have positive static stability as compared to the negative static stability of the conventional fixed-pitch rotor; partial blade stall during pull-ups or upward gusts may be avoided in spite of a high and economic thrust coefficient in steady flight, and no adjustment of the collective pitch control is required for the transition from powered flight to autorotation. The rotor with pitch-cone change, because of its inherent stability, promises, without recourse to external stabilizing devices, appreciably improved flying qualities of the helicopter.

Approximate Solutions for Shock Waves in a Steady, One-Dimensional, Viscous and Compressible Gas

By

Paul Lieber, Frank Romano, and Henry Lew

Polytechnic Institute of Brooklyn

In this paper the equations of motion for a steady, one-dimensional, viscous and compressible gas are simplified according

to two procedures and are then integrated. In one procedure the viscosity term is retained in the momentum equation and omitted in the energy equation. In the second procedure the viscosity term is omitted in the momentum equation and retained in the energy equation.

The equations used in the first case are the momentum equation into which is introduced the frictional force [$= (4/3)\mu d^2u/dx^2$], the continuity equation, and a polytropic relationship between pressure and density, the last expression replacing the energy equation in its usual form. The value of the exponent n, in the polytropic relationship for which the Rankine-Hugoniot points are satisfied, is shown to be a function of the initial Mach Number, M_0, only. It is strongly indicated that retaining the viscosity terms in the momentum equation and neglecting them in the energy equation would offer a significant and considerably simplified mathematical representation of a steady compressible viscous flow in two and three dimensions.

In the second case, the Eulerian equation, together with the continuity and energy equations for a one-dimensional motion, describe approximately the flow of a viscous, heat-conducting gas. This is analogous to the treatment of Boley and Lieber for two-dimensional flow.

An exact solution is obtained for the shock-wave structure in both cases, and, although the velocity distribution in the latter case is continuous everywhere, the singularity in the velocity gradient is not removable. However, while the present report shows that retaining the viscous term in the energy equation alone is not sufficient for the removal of this singularity, it is shown that the frictional force, when considered in the momentum equation, does remove the singularity. Since the shock-wave thickness, according to the Prandtl definition, is zero in the second treatment (a physical impossibility), it was not found necessary to calculate the variation of the remaining flow variables (p, ρ, S, T) with Mach Number.

Good agreement with the exact one-dimensional solutions of Morduchow and Libby and H. Reissner and Meyerhoff with regard to the structure of the shock wave and its thickness is obtained when the effect of viscosity is considered only in the momentum equation. Moreover, indications are such as to justify the conclusion that the presence of the viscous stress term in the momentum equation is a necessary condition for the removal of the singular velocity gradient in one-dimensional flow.

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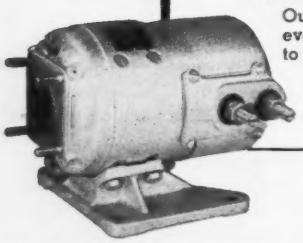

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A Method of Determining Some Aerodynamic Coefficients from Supersonic Free-Flight Tests of a Rolling Missile

By

Ray E. Bolz and John D. Nicolaides

Rensselaer Polytechnic Institute and Ballistic Research Laboratories, Respectively

Based on the assumption that the aerodynamic forces acting at any point on a lifting surface are linearly dependent upon the local angle of attack at that point, the theory of pure rolling motion is applied to the experimentally observed motion of a finned missile in supersonic flight in order to (1) determine how well the actual motion is represented by the theory; (2) determine the suitability of the Aerodynamic Range at the Ballistic Research Laboratory, Aberdeen, Md., to the proposed free-flight roll technique; and (3) determine certain aerodynamic coefficients associated with the motion over a range of Mach Numbers from 1.67 to 2.7. Values for the aerodynamic coefficients are also derived using the linearized supersonic theory and are compared with those obtained from experiment.

The results indicate that the actual motion is well represented by the theory to

within the small experimental errors and that excellent reproducibility of the aerodynamic coefficients in roll is obtained. Furthermore the results show a fairly good correlation with the linearized theory when applied to aerodynamic surfaces of 16 per cent thickness as employed on the missiles used in the reported tests.

Turbulent Boundary-Layer Characteristics at Supersonic Speeds—Theory and Experiment

By

Robert E. Wilson

Defense Research Laboratory, The University of Texas

Turbulent boundary-layer characteristics at supersonic speeds have been experimentally determined from Pitot pressure surveys made at several stations along a flat plate, and the data are compared with theoretical results.

The theory is based on the assumption that von Kármán's differential equation for the velocity distribution in the incompressible boundary layer applies for compressible flow when the variation in density through the boundary layer is taken into account. Taking the case of a thermally insulated flat plate and neglecting radiation effects, a relation between mean turbulent skin-friction coefficient and Reynolds Number is derived, and the relation appears to be valid throughout the test range of Mach Numbers and Reynolds Numbers.

The check between theory and experiment is limited by the maximum test values of Mach Number and Reynolds Number, which are approximately 2.2 and 19×10^6, respectively. The theory is expected to be valid at Reynolds Numbers higher than 19×10^6 for Mach Numbers within the test range. However, the validity of the theory for Mach Numbers greatly in excess of 2.2 should be checked by further experiments.

The Quasi-Steady Air Forces for Use in Low-Frequency Stability Calculations

By

Martin Goland

Midwest Research Institute

Simple, approximate expressions are derived for the air forces acting on an airfoil executing oscillatory motions with arbitrary damping. These expressions are in forms convenient for use in analyses of aircraft stability and response. The derivations are of a simple character, consisting merely of power series approximations for the known results from unsteady aerodynamic theory. It is shown that the present approach enables the evaluation of aircraft stability derivatives with better

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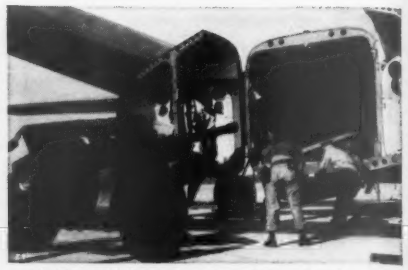

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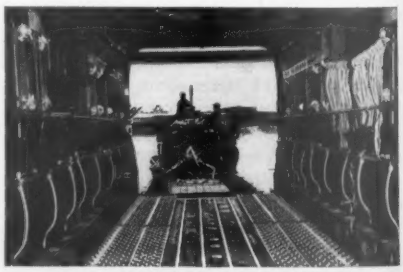

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theoretical accuracy than do the methods now conventionally employed, while not appreciably increasing the labor associated with their use. In the present paper, detailed attention is concentrated on the determination of the stability derivatives for low-frequency motions; preliminary consideration is also given to methods for dealing with the higher frequency range.

Periodic Motions of a Rectangular Wing Moving at Supersonic Speed

By

H. J. Stewart and Ting-Yi Li

California Institute of Technology

The determination of the air forces and moments on an oscillating airfoil in a main stream of uniform supersonic speed is important because of its vital role in the prediction of the flutter and aerodynamic instability characteristics of high-speed aircraft and supersonic missiles. In the past, calculations concerning this problem were performed mostly on the basis of an analysis of a two-dimensional wing of infinite span. A satisfactory theory of the corresponding problem for a three-dimensional wing with finite span is not yet available. In a previous paper, the present authors developed some general integral expressions for the disturbance velocity potential of a three-dimensional oscillating wing with both purely supersonic and mixed boundary conditions. The method used was essentially that of Evvard. These general results are applied in the present paper to determine the lift and the moment (due to the lift) acting upon a thin oscillating wing of rectangular plan form moving at a supersonic speed. Detailed analysis in the case of vertical oscillations is presented. Progress in the analysis of pitching oscillations is also indicated.

A fundamentally different method of approach to the oscillating rectangular wing problem has been presented by Miles. The numerical results presented here are consistent with results (not yet published) obtained by his method. A method similar to that used here is being used by C. C. Chang to compute an approximate solution of rectangular wing problems.

Lift on Inclined Bodies of Revolution in Hypersonic Flow

By

G. Grimminger, E. P. Williams, and G. B. W. Young

The RAND Corporation

The importance of body lift lies in the fact that at moderate angles of attack and high Mach Number it can constitute an appreciable part of the total lift of a winged missile. In this paper an attempt has been made to analyze body lift in hypersonic flow by an approximate method and, together with a correlation of existing experimental data, to indicate the probable variation of body lift over a wide range of Mach Numbers extending from low supersonic to hypersonic. The method of analysis of hypersonic flow over inclined bodies of revolution employed herein has been denoted as the *hypersonic approximation*. It is an improvement on the Newtonian corpuscular theory of aerodynamics, since it considers the centrifugal forces resulting from the curved paths of the air particles in addition to the impact (Newtonian) forces.

Conical Flow Methods Applied to Uniformly Loaded Wings in Subsonic Flow

By

Seymour Lampert

Ames Aeronautical Laboratory, N.A.C.A.

Conical flow solutions for Laplace's equation are employed which yield expressions for the contour of uniformly loaded lifting surfaces at subsonic speeds. By properly superposing these conical flow fields, it is possible to determine the twist and camber for uniformly loaded wings having various aspect ratios, taper ratio, and sweepback. The solutions derived may also be used to investigate wing contours necessary for various types of spanwise and chordwise load distributions.

On the Thickness of a Steady Shock Wave

By

R. von Mises

Harvard University

A simple formula is derived, not requiring any elaborate integration, which gives exact and narrow limits for the extension of the transition layer in the one-dimensional, viscous, heat-conducting steady flow. The method employed also lends itself to a quick survey of all possible flow patterns.

Analytical and Experimental Studies on Dynamic Loads in Airplane Structures During Landing

By

T. H. H. Pian and H. I. Flomenhoft

Massachusetts Institute of Technology and Bureau of Aeronautics, Navy Department

Two assumptions are made in the analytical method for determining the transient stresses in airplane structures during landing. The first assumption, that the landing impact forces are independent of the response of the structure, is justified by a simple analytical study. The second assumption, that the damping and aerodynamic forces can be neglected, is verified by comparing the results of wind-on and wind-off drop tests of a model wing in a wind tunnel. The total transient stress is considered to be the sum of the stresses that would result if the system were restrained against vibrating and the additional stresses that result from the vibratory motion. This method has been made more suitable for practical application by the use of a transient analyzer. The drop tests also provide an experimental check on the analytical method.

The Longitudinal Stability of Elastic Swept Wings at Supersonic Speed

By

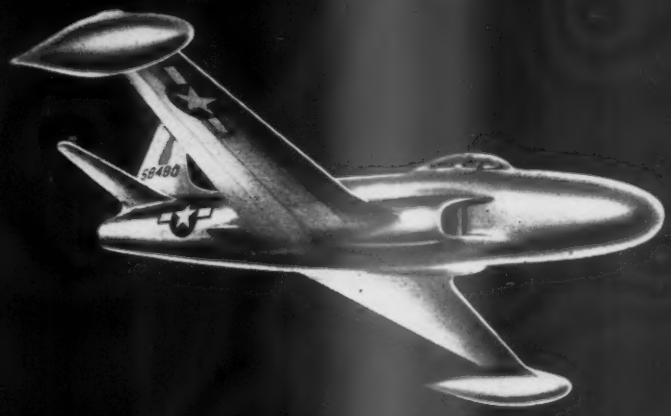
C. W. Frick and R. S. Chubb

Ames Aeronautical Laboratory, N.A.C.A.

The longitudinal stability characteristics of elastic swept wings experiencing bending and torsional deformations are calculated for supersonic speed by the application of linearized lifting-surface theory. A parabolic wing deflection curve is assumed, and the analysis is simplified by considering the wing panels to be simple cantilever beams. The method is thereby limited in application to wings of high aspect ratio for which the root effects are small. Expressions for the lift, pitching moment, and span load distribution are derived in terms of the elastic properties of the wing—namely, the design stress, the modulus of elasticity, the shearing modulus, and the maximum design load factor. The analysis applies to wings with leading edges swept behind the Mach lines. In all cases, however, the trailing edge is sonic or supersonic.

The validity of the assumption of a parabolic deflection curve is investigated by comparison with matrix calculations for a wing with the moment of inertia varying with the fourth power of the spanwise dimension. It is shown that for such wings the assumption of a parabolic deflection curve gives valid results for the wing stiffnesses and flight conditions in which the designer is primarily interested.

Calculations made for subsonic speed, when compared with the results for supersonic speed, indicate that, except for the effects of the change in the chordwise position of the section center of pressure, the aeroelastic characteristics are primarily a function of the flight dynamic pressure and not of Mach Number, at least for wings that have subsonic leading edges at all flight Mach Numbers.



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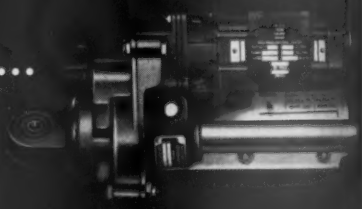

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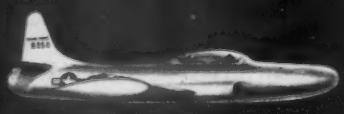

Lear

Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

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German-English Technical Dictionary. Edited by Kurt F. Leidecker 71

Reviewed by Maurice H. Smith, Librarian, I.A.S.

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Publications Reviewed

The following periodicals currently provide source material for the Reviews Section of the *Aeronautical Engineering Review*. Received regularly, these magazines and reports (both domestic and foreign) are thoroughly screened each month by the Institute's technical editorial staff. Articles and items of technical value to the aeronautical profession are abstracted or listed for further reference.

Not included in this list are hundreds of irregularly published reports, releases, house organs, etc., which are also screened and reviewed as they appear. Unless otherwise indicated, the publications in this list are issued in the U.S. All publications reviewed are permanently filed in the I.A.S. libraries.

Trade Publications—English Language

Aero Digest
Aeronautics (England)
The Aeroplane (England)
Aeroporika Nea (Greece)
Air Affairs
Air Facts
Air Trails Pictorial
Air Transportation
Aircraft (Australia)
Aircraft & Airport (Canada)
Aircraft Engineering (England)
Aircraft Production (England)
The Air-Log (Australia)
Airports & Air Transportation (England)
American Aviation
American Helicopter
Applied Hydraulics
Audio Engineering
Automotive Industries
Aviation Operations
Aviation Week
Canadian Aviation (Canada)
Diesel Power & Diesel Transportation
Distribution Age
Electronic Engineering (England)
Electronics
The Electronics Forum (England)
The Engineer (England)
The Engineers' Digest
The Engineers' Digest (England)
Flight (England)
Flying
Flying (New Zealand)
The Indian Airman (India)
Indian Skyways (India)
Instruments
Machine Design
Maritime & Aviation Magazine (Ireland)
Materials & Methods
Modern Metals
Modern Transport (England)
The Philosophical Magazine (England)
Product Engineering
Radio & Television News
Sailplane & Glider (England)
Sheet Metal Industries (England)
Skyways
Southern Flight
Steel Processing
U.S. Air Services
Western Flying
Whites Aviation (New Zealand)
Wings (Australia)

Trade Publications—Foreign Language

Aeronáutica (Venezuela)
Aeronáutica Continental (Argentina)
Les Ailes (France)
L'Air (France)
L'Ala (Italy)
Alata (Italy)
Argentina Aérea (Argentina)
Avia (Argentina)
Aviação (Brazil)
Aviación (Argentina)
L'Aviation Marchande (France)
Avión (Spain)
Chile Aéreo (Chile)
L'Echo des Ailes (Belgium)
Flugwehr und -Technik (Switzerland)
Ilmailu (Finland)
Ingeniería Aeronáutica (Spain)
Inter-Auto (Italy)
Interavia (Switzerland)
La Médecine Aéronautique (France)
Mundo Aeronáutico (Argentina)
Propel (Denmark)
Revista Aérea Cubana (Cuba)
Revista Aérea Latinoamericana (U.S.)
Revista Nacional de Aeronáutica (Argentina)
Revue Générale de l'Air (France)
Rivista di Meteorologia Aeronautica (Italy)
Romania Aeriana (Romania)
Schweizer Aero-Revue (Switzerland)
Tecnica Italiana (Italy)
Teknikens Värld, med Flyg (Sweden)
Thermik (Germany)
Velocidade (Brazil)
De Vliegende Hollander (Netherlands)
Vliegwereld (Netherlands)
Vingpennor (Sweden)
Weltluftfahrt (Germany)

Society, University, and Specialized Publications

Acta Polytechnica, Chemistry, Including Metallurgy, Series (Sweden)
Acta Polytechnica, Civil Engineering and Building Construction Series (Sweden)
Acta Polytechnica, Engineering Series (Sweden)
Acta Polytechnica, Mathematics Series (Sweden)
Acta Polytechnica, Mechanical Engineering Series (Sweden)
Aéro Club de France, Revue (France)
Aero Research Technical Notes (England)
Aeronautical Engineering Review
The Aeronautical Quarterly (England)
Aeronautical Society of India, Journal (India)
L'Aerotecnica (Italy)
Agricultural & Mechanical College of Texas, Engineering Experiment Station, Bulletin
Aircraft Heating Digest
Allis-Chalmers Electrical Review
American Chemical Society, Journal
American Journal of Physics
American Meteorological Society, Bulletin
American Rocket Society, Journal
A.S.T.M. Bulletin
A.S.M.E. Transactions
Analytical Chemistry
Antiaircraft Journal
Astro-Jet
The Bee-Hive
The Bell System Technical Journal
Boeing Magazine
Boeing Service Guide
British Interplanetary Society, Journal (England)
British Journal of Applied Physics (England)
Les Cahiers d'Aérodynamique (France)
Canadian de Havilland Gazette (Canada)
Chemical & Engineering News
Chinese Journal of Physics (China)
Círculo de Aviación, Revista (Argentina)
Club de Turismo Venezolano, Revista (Venezuela)
Communications on Pure and Applied Mathematics
Cornell Aeronautical Laboratory, Inc., Translations
Corrosion
Cranfield, College of Aeronautics, Reports (England)
de Havilland Gazette (England)
Delft, Technische Hogeschool, Laboratorium voor Aero- en Hydrodynamica, Mededelingen (Netherlands)
Douglas Service
Electrical Communication
Electrical Engineering
The Engineering Journal (Canada)
Ericsson Technics (Sweden)
Esso Air World (England)
Franklin Institute, Journal
General Electric Review
Guild of Air Pilots and Air Navigators, Journal (England)
Hawker Siddeley Review (England)
Helicopter Association of Great Britain, Bulletin (England)
I.A.S. Sherman Fairchild Publications
Illinois Technograph
Illinois University, Bulletin, Bulletin Series

Illinois University, Bulletin, Circular Series
Illinois University, Institute of Aeronautics, Bulletin
Industrial & Engineering Chemistry
Industrial Quality Control
Institut Royal Météorologique, Mémoires
Institut Royal Météorologique, Miscellanées
Institute of Navigation, Journal (England)
Institute of Radio Engineers, Proceedings
Institute of Transport, Journal (England)
Institute of Welding, Transactions (England)
Institution of Electrical Engineers, Proceedings, Part III, Radio and Communications Engineering (England)
Institution of Mechanical Engineers, Proceedings (England)
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Istanbul, University, Faculty of Science, Revue, Series A: Mathematics, Physics, and Chemistry (Turkey)
Istanbul, University, Faculty of Science, Revue, Series B: Physical Natural Science (Turkey)
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Journal of Southern Research
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Journal Scientifique de la Météorologie (France)
The Log (England)
Lubrication
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The National Air Review
National Fire Protection Association, Committee on Aviation and Airport Fire Protection, Bulletin
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Rivista di Medicina Aeronautica (Italy)
Rocketscience
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France

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La Recherche Aéronautique

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Inter-Services Aircraft Recognition Journal
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Netherlands

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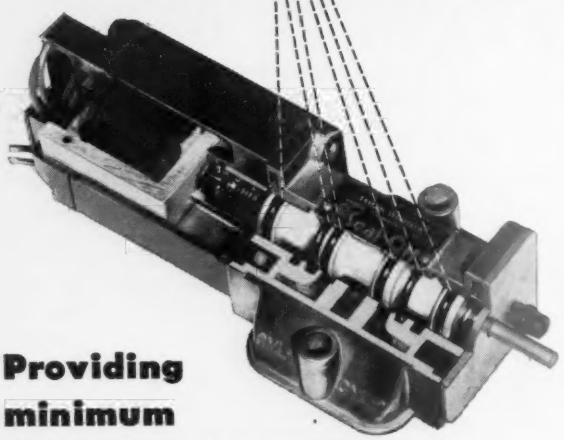

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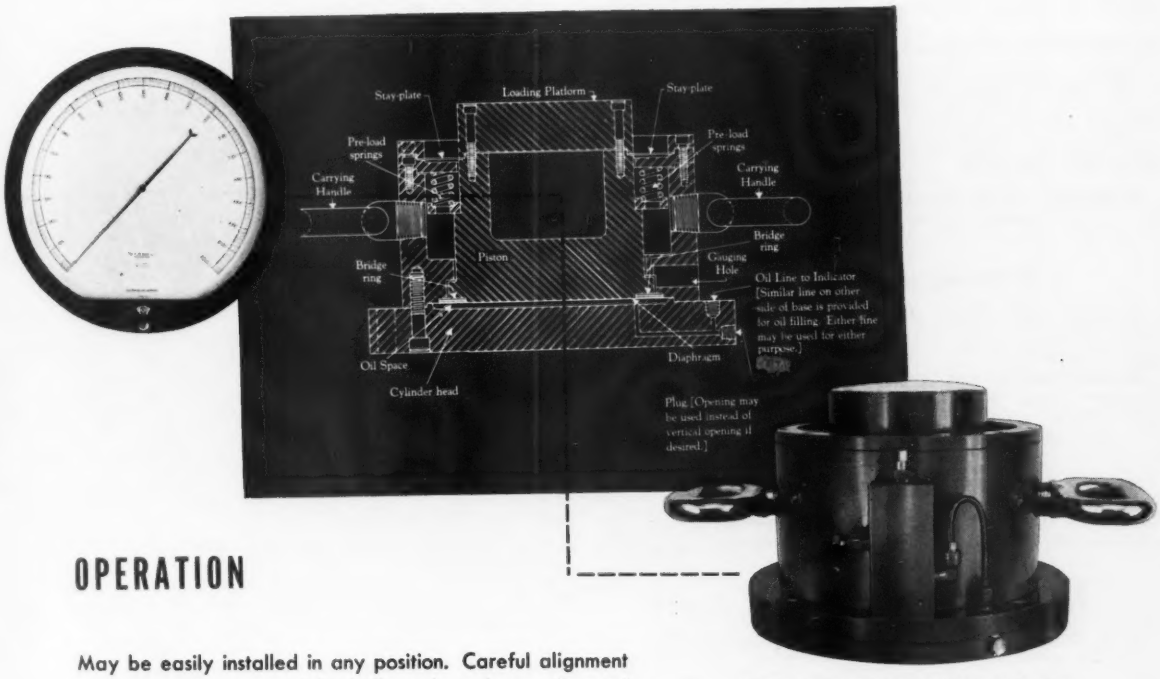

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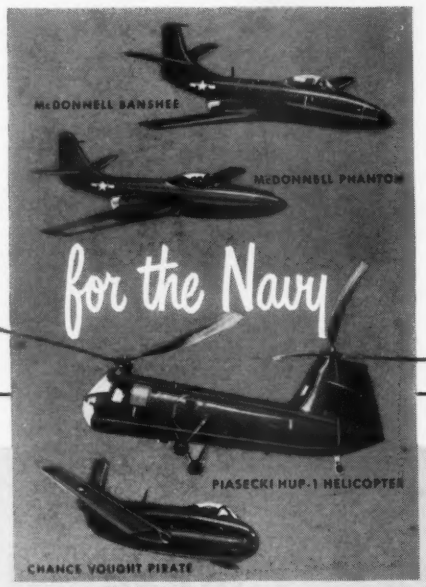

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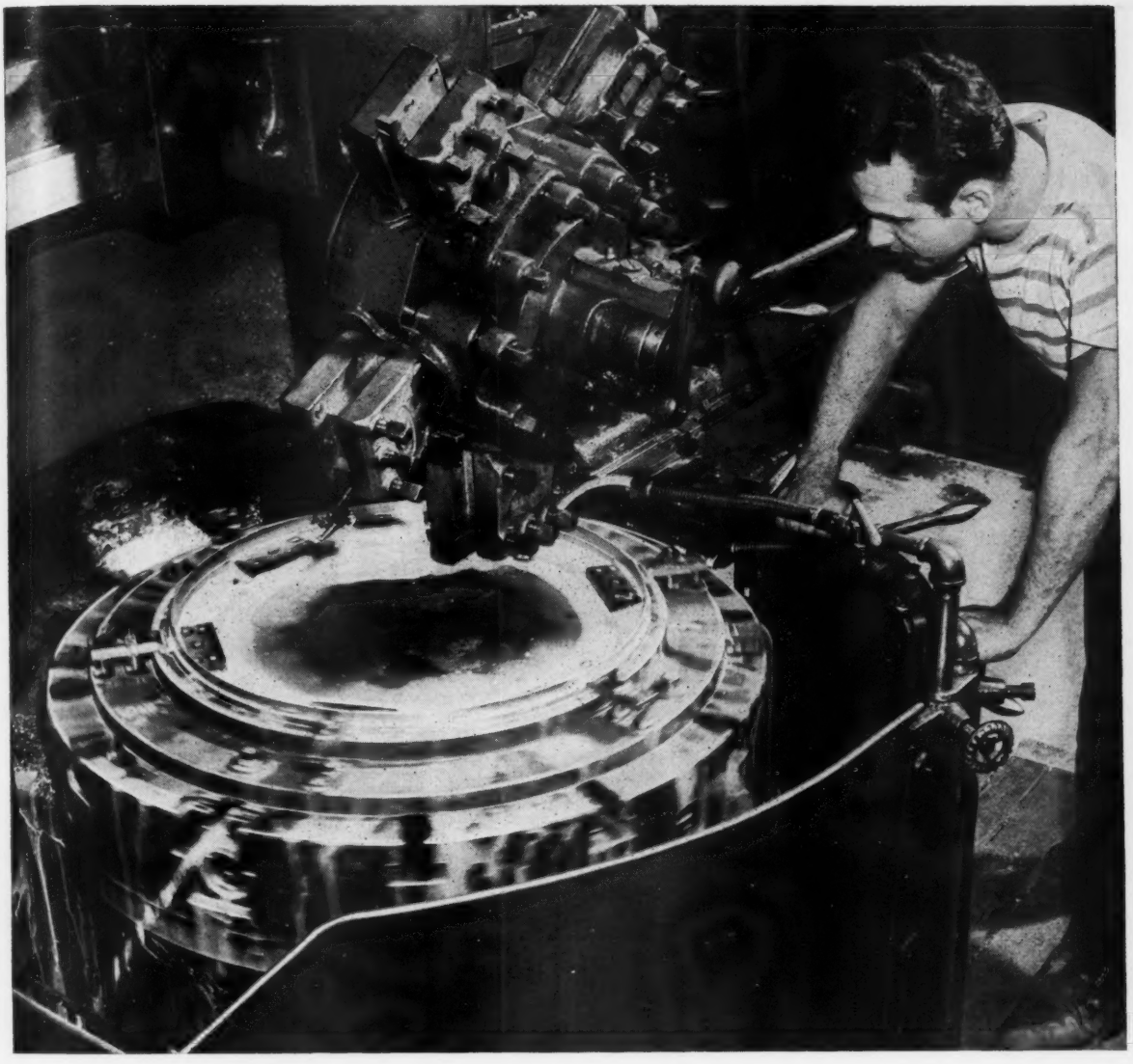

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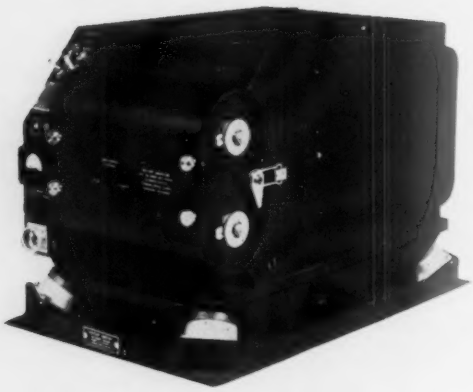

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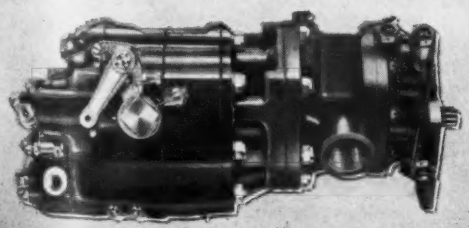

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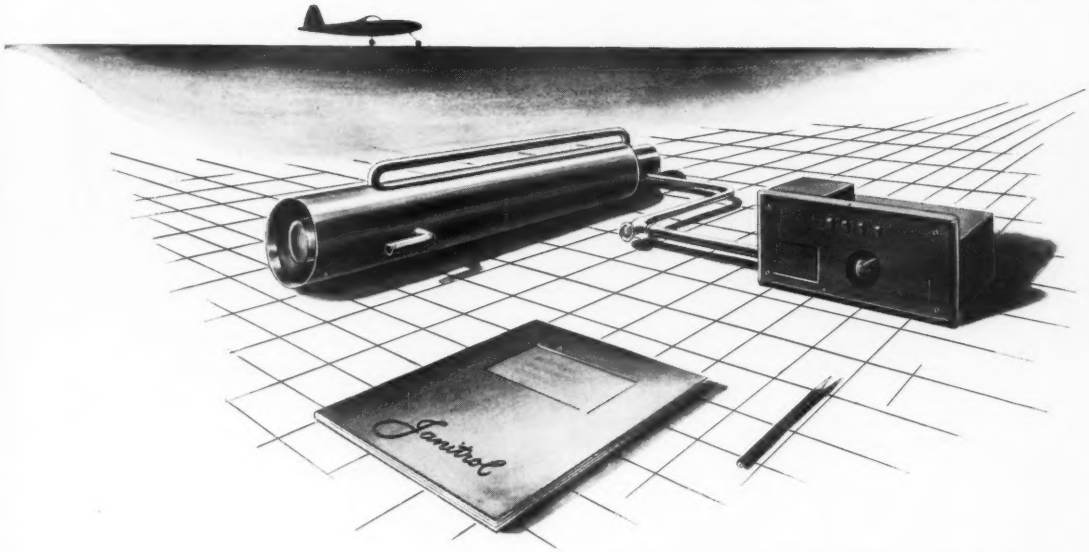

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On Bending of Curved Thin-Walled Tubes. Eric Reissner. *National Academy of Sciences, Proceedings*, Vol. 35, No. 4, April, 1949, pp. 204–208. 7 references. (Reprint.)

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Some Pertinent Design and Performance Problems Involved in the Construction of a Supersonic Wind Tunnel. Matthew A. Sutton. *Ohio, State University, Engineering Experiment Station News*, Vol. 22, No. 1, February, 1950, pp. 21, 22, 41–43, illus.

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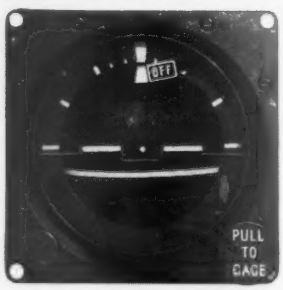

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Aeronautical Reviews — BOOKS

Elements of Practical Aerodynamics

By Bradley Jones. 4th Ed. New York, John Wiley & Sons, Inc., 1950. 444 pp. $5.00.

It was with mixed feelings that this reviewer took the Third Edition of Professor Bradley Jones' book, *Elements of Practical Aerodynamics*, off his shelf and substituted the 1950 Fourth Edition that has just come off the press. Having used this work as a practical reference for eight years, sometimes several times a day, it was like parting with an old and trusted friend. Yet, the time had come to make a complete revision of this volume since, in the last eight years, not only aeronautics but also the methods of teaching it have advanced greatly.

In 1936, and subsequently in 1939 and 1942, Professor Jones presented the material in such a way that any undergraduate, even the one who did not know calculus, could use it. In the fourth edition he presupposes the knowledge of calculus, and the contents of the book became clearer and still more readable.

The previous editions contained such chapters as "Unconventional Types of Aircraft," "Materials and Construction," "Instruments," "Navigation," and "Aerostatics." It is good that Professor Jones omitted these chapters from the Fourth Edition, since they form a specialized subject today. He added, however, an interesting treatment of flow phenomena and methods of determining pressure distribution; further, he included a chapter on scale and compressibility effects. Noteworthy also is another new chapter dealing with dynamic stability. Professor Jones' uncanny ability to present complex manifestations in simple language comes to its highest pitch in this welcome addition to the theory of stability. It is a difficult subject, and yet he introduces it in about ten pages, in such a way that any student knowing the rudiments of differential equations and high algebra can follow it and get a clear idea of what happens when a disturbed airplane returns to its normal flight path.

The format of the book has been made smaller, the type more legible. All the problems and examples have been completely reworked and brought up to date. Most of the charts and tables have been extended to cover the altitudes, air speeds, and horsepowers encountered in today's flying. Another improvement over the former editions is the fact that subheadings and formulas are presented in the decimal system.

In publishing this Fourth Edition of his work, Professor Jones has again produced a book that will become a standard text in many schools of aeronautics. It lives up to its title, since it is a *practical* treatise, not only for the teacher and the student, but for the engineer who can check his actual calculations with the hundreds of *numerical* examples that Professor Jones gives in this volume.

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German-English Technical Dictionary

Vol. 1, A-K. Edited by Kurt F. Leidecker. New York, S. F. Vanni, 1950, Vol. 1, 494 pp. $35 per set of 2 vols.

This dictionary, to be completed in 1950 in two volumes, grew out of the screening and processing of captured air technical German documents, begun in 1945 in London at the Air Documents Research Center under Col. H. M. McCoy. This work was continued at Wright-Patterson Air Force Base, Dayton, O., by the Air Documents Division, Intelligence, T-2, Air Materiel Command, now the Central Air Documents Office, Navy-Air Force, under Col. A. A. Arnhym. A first interim edition was published in August, 1946 and a second interim edition in 1947. Dr. Leidecker was one of the scientists brought to London to assist in the project and was chief of the dictionary unit from its beginning until its discontinuance in 1947.

The subjects covered, as claimed on the title page, are aeronautics, rocketry, space navigation, atomic physics, higher mathematics, jet engines, turbines, hydraulics, petroleum industry, civil and mechanical engineering, ballistics, electronics, radio, radar, aerial photography, television, infrared research, communication, meteorology, topography, and aviation medicine. Such other specific fields as instruments for aircraft, engines, production, shop and testing, navigation and meteorology, or elasticity, vibrations, ordnance, armament, and materials seem to be adequately covered. The value of the dictionary lies in its inclusion of the fields related to aeronautical engineering and in its development from actual documents reflecting the latest German research. The term *Düse*, for example, is given with six meanings: blast pipe, nozzle bell pipe, orifice, jet, tuyere, and spray, and there are 50 other words beginning with *Düsen*. Abbreviations are included, and theoretical terms, which are largely lacking in aeronautical dictionaries, are liberally included. The present volume contains more than 48,000 German words and one or more English equivalents of each. This dictionary can be recommended as most useful and practical for any one concerned with the English meanings of technical and scientific German words.

MAURICE H. SMITH
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Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

Book Notes

AERONAUTICS, GENERAL

Aeronautical Papers, 1885-1945. Albert F. Zahm. Notre Dame, Ind., University of Notre Dame Press, 1950. 2 Vols. $15 per set.

These two volumes contain 142 papers published by Dr. Zahm from 1885 through 1945, including his tenure from 1917 to 1929 as Director of the Navy Aerodynamical Laboratory and as chief of the Aeronautics Division of the Library of Congress beginning in 1930. The analytical papers cover a wide range of original research topics in aerodynamics, instruments, airplane components, and stress analysis, and there is a wide coverage of subjects among the descriptive technical papers. Dr. Zahm's historical articles are also included.

AVIATION MEDICINE

Essai de Classification Documentaire de Médecine Aéronautique. L. Gallouin. Paris, L'Expansion Scientifique Française, 1949. 48 pp.

This system of classification for aero-medical literature is based upon the classification in use at the Centre d'Études de Biologie Aéronautique du

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Service de Santé de l'Air in Paris. The classification consists of eight general divisions each broken down in detail (9 pages), and there is an alphabetical index of 18 pages. A survey of the bibliography of aviation medicine is included.

ELECTRONICS

Industrial Electronics. Harold W. Ranney. Albany, N.Y., Delmar Publishers, Inc., 1949. 213 pp., illus. $4.00.

The author's aim is to furnish a textbook on the fundamentals of vacuum tubes in electric circuit control. The field of communications electronics is largely omitted. The reader is required to have a knowledge of electric circuits, direct and alternating currents, and electric measuring instruments. The author is Supervisor of Industrial Teacher Training in the New York State Education Department.

Threshold Signals. Edited by James L. Lawson and George E. Uhlenbeck. (Massachusetts Institute of Technology, Radiation Laboratory Series, No. 24). New York, McGraw-Hill Book Company, Inc., 1950. 388 pp., illus., diagrs. $5.00.

The authors' main purpose is to consider fundamental noise and interference limitations in receiving systems, and to determine the effect of the various parameters in the receiving system on the detectability of signals. The common types of radiation in the fields of radio, television, communications, and radar and the process of reception applicable to each are presented.

Aerials for Centimetre Wave-Lengths. D. W. Fry and F. K. Goward. Cambridge, Mass., and New York, Cambridge University Press, 1950. 172 pp., diagrs. $3.50.

Written for the radar design engineer and the general radio research worker or student, this book aims to review developments in centimetric antenna technique, with particular reference to work at the Telecommunications Research Establishment beginning about 1941. Emphasis is placed on design principles and on the advantages of particular types of antennas for particular requirements. Though a design handbook is not attempted, typical dimensions and measurements are usually given, and illustrative examples of methods of approach, with mathematics kept to a minimum. Scanning antennas are discussed primarily, with a final chapter on directive and omnidirectional types. A list of about 33 references, principally British, is included.

Short-Wave Radio and the Ionosphere. T. W. Bennington. 2nd Ed. London, Published for *Wireless World* by Iliffe & Sons, Ltd., 1950. 138 pp., illus., diagrs. 10*s.* 6*d.*

The first edition of this book was published in 1944 as *Radio Waves and the Ionosphere.* This edition has been completely rewritten and reset in new type, with 56 new illustrations. The role of the ionosphere in relation to short-wave radio communication is discussed with special reference to everyday practical problems. Mathematics is avoided, and physical processes are discussed in simple descriptive language. The author is associated with the Engineering Division of the British Broadcasting System.

A Dictionary of Electronic Terms. Edited by Harry L. Van Velzer. Chicago 7, Ill., Allied Radio Corporation, 1950. 63 pp., illus. $0.25.

Over 2,500 terms used in television, radio, and industrial electronics are defined, and about 125 components, circuits, and pieces of equipment are illustrated. Definitions vary from a few words to as many as 75 or more for terms requiring fuller definition.

Electronics, Principles and Applications. Ralph R. Wright. New York, Ronald Press Company, 1950. 387 pp., illus., diagrs. $5.50.

This textbook originated from the requirements of a course for nonelectrical engineering students but can be used by electrical engineering and physics students. While at least one course in electrical engineering is required of the reader, a brief review is included of d.c. and a.c. circuits. The first three chapters deal with electronic principles, and the final three-fifths of the book is devoted to basic applications of electron tubes and

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electronic circuits. Bibliographies are included at the ends of chapters, and indexes of names and subjects are provided. The author is Associate Professor of Electrical Engineering at the Virginia Polytechnic Institute.

ENGINEERING PRACTICES

Engineering Reports. Lisle A. Rose, Burney B. Bennett, and Elmer F. Heater. New York, Harper & Brothers, 1950. 341 pp., figs. $3.00.

This textbook aims to cover the types of report communication needed by the engineer on the job, written and oral, including articles on technical subjects prepared for publication. Part I, Increasing Your Active Resources, deals with general considerations including fact collecting and evaluating. Part II, Applying Your Resources, covers the use of language and ways of amplifying statements by illustrative material. Part III discusses various forms of digest and correspondence related to the report, and the final three parts cover in detail written and oral reports, and technical articles. Professors Rose and Heater are associated with the University of Illinois, and Professor Bennett with the Michigan College of Mining and Technology.

EQUIPMENT

ELECTRICAL

Design Manual on Aircraft Electrical Installations. Airworthiness Requirements Committee on Electrical Installations. Washington, Aircraft Industries Association, 1950. 56 pp. $1.75.

Although basically prepared for transport category aircraft, this manual is generally applicable also to other types of commercial airplanes and to military airplanes. The greater part of the book is devoted to 16 design guide chapters, dealing with circuit protection, fail-safe features in circuits, circuits for essential equipment, multiengine reliability, feed-through connections and terminations, grounding and bonding, cable selection and routing, aluminum cable and connections, cable identification, maintenance of electrical equipment, operation and inspection of electrical equipment, space provisions for expansion of electrical equipment, equipment selection and installation, corrosion prevention, system load distribution, and electrical system tests. Tables of cable gages and the current carrying capacity of copper and aluminum cables and of time-current characteristics for cables are included. There is a bibliography of specifications and design papers.

LAWS & REGULATIONS

Legal Phases of Engineering: Contracts and Specifications. Ivan C. Crawford. New York, The Macmillan Company, 1950. 346 pp. $3.75.

This textbook is designed to acquaint the student with legal relations peculiar to the engineering profession, to show the process of the court in reaching a final decision, and to develop an appreciation of clear and concise contracts and specifications. Examples are given to illustrate the discussions on contracts, and cases are used to illustrate court processes. The author is Dean of the College of Engineering at the University of Michigan.

PHOTOGRAPHY

Handbook of Aerial Mapping and Photogrammetry. Lyle G. Trorey. Cambridge, Mass., and New York, Cambridge University Press, 1950. 178 pp., figs., illus. $5.00.

Planned for the map maker working from aerial photographs, this handbook breaks down the recommended procedures into detailed unit operations, using drafting methods that have been proved in practice. Tilted photographs are treated by mathematical analysis rather than optical projection, and the solutions require only simple devices measuring in the planes of the photographs. The methods described were evolved during the war, in work with the Canadian Military Survey, to solve problems of extensive mapping with speed and accuracy. A bibliography of 19 books and papers is included.

POWER PLANTS

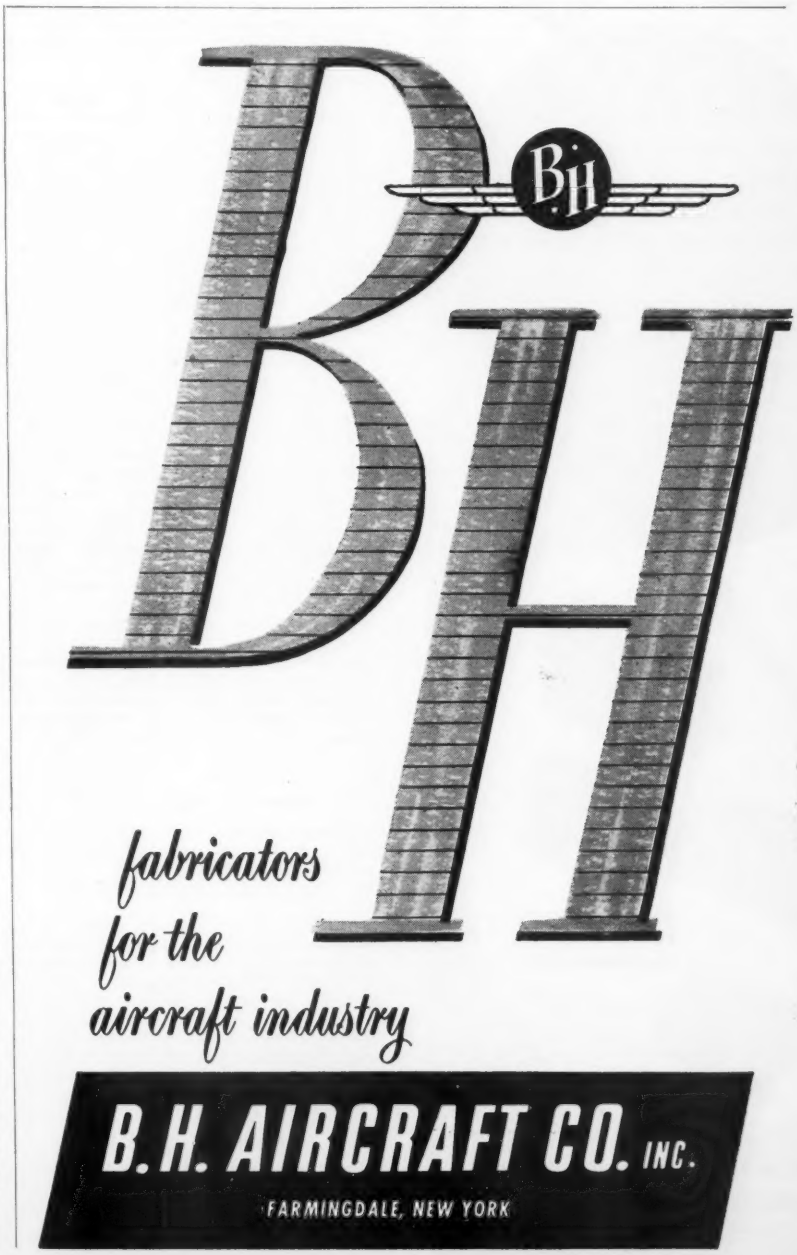
JET & TURBINE

Jet Propulsion: Turboprops. Volney C. Finch. Millbrae, Calif., The National Press, 1950. 256 pp., illus., diagrs. $5.00.

Designed for the student, this textbook includes both fundamentals and appropriate descriptive material on current turboprops. The author's aim is to provide the required understanding of present methods of application and knowledge of practical standards and procedures for the teaching of current design practice, along with material for the mastery of theory. Following introductory chapters on the applications, limitations, and possibilities of the turboprop in aircraft propulsion and its mechanics and performance evaluation, the discussion takes up design considerations. Chapters 5 through 12 deal with the gas turbine, including blade path, design of the individual gas turbine stage, turbine blade ring analysis, blade design, two-dimensional flow through cascades of blades, high-temperature alloys, disc design, and stress analysis. There are two chapters on combustion, and the final three chapters are concerned with compressors. Bibliographies at ends of chapters refer to about 225 papers and books, and there is a good index. Professor Finch is a member of the mechanical engineering faculty at Stanford University.

Jet Propulsion. H. G. Wintersteen. Scranton, Pa., International Textbook Company, 1950. 64 pp., diagrs. $1.00.

This book, planned for the layman, presents a rounded account of reaction propulsion principles, including physical properties of the atmosphere, application of basic laws to jet propulsion, and basic power-plant design and construction. The final two-thirds of the book is concerned with turbojet and rocket power units, with brief sections on pulse-jet and ram-jet types. The illustrative diagrams are excellent.



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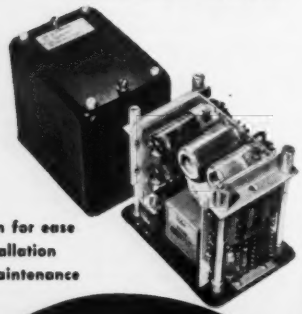

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PRODUCTION

Punches and Dies; Layout, Construction and Use. Frank A. Stanley. 4th Ed. New York, McGraw-Hill Book Company, Inc., 1950. 583 pp., illus., diagrs. $4.75.

This book was first published in 1919 and was last revised in 1943. The present edition contains about 72 pages of new material, including data on dies for piercing, notching, and other purposes with cemented carbide inserts, and press tools designed especially for stainless steel piercing and blanking operations. Detailed descriptions of deep drawing processes, as developed in the manufacture of steel cartridge cases and applied in the aircraft and other industries, the Guerin process, cast dies, and large multiple piercing dies are typical of other new material.

Industrial Inspection Methods. Leno C. Michelon. Revised Ed. New York, Harper & Brothers, 1950. 566 pp., illus. $6.00.

This revised edition of a textbook first published in 1942 is larger by more than 170 pages. The author points out that since 1942 quality control terminology and specifications have become standardized, and industrial inspection has become an integral part of the production process. New inspection tools and devices to meet quality standards for thousands of intricate parts have been developed, and engineering tolerances, tooling, and raw materials have come under exacting statistical scrutiny. While this edition basically resembles the earlier one, the growth of the subject made necessary a practically new book. Questions are included at the ends of chapters, and useful tables and lists of over 150 books, 25 manufacturers' catalogs and technical bulletins, and over 60 visual aids are included. The author teaches at Purdue University.

Welding Handbook. 3rd Ed. New York, American Welding Society, 1950. 1,651 pp., illus., tables. $12.

This new edition of a handbook last revised in 1942 is made considerably larger by the use of a two-column page and contains 62 chapters by more than 250 authorities. The first 27 chapters deal with over 30 welding and cutting processes used currently in industry. There are 13 chapters on the ferrous and nonferrous metals commonly welded, including their properties and how to weld them by different welding processes. Applications are covered in 11 chapters on such specific industries as aircraft, pressure vessels, machinery construction, and industrial piping. The chapter on aircraft, by a committee of 13 specialists, is increased to 30 pages and includes a bibliography of specifications for filler metal and flux, process and inspection methods, and 31 articles on American practice. Additional chapters cover cost estimating, the physics of welding, welding metallurgy, terms and definitions, tables, standards, symbols, filler metal specifications, and standard tests for welds. About 300 tables are included, and there is a detailed subject index of 69 pages.

ROTATING WING AIRCRAFT

Designs for Helicopters. Supplement to Designs for Helicopters. I. B. Laskowitz. Brooklyn 25, N.Y., 284 Eastern Parkway, The Author, 1947, 1950. 2 Vols. 23, 9 pp., illus. $2.50 per set.

The 1950 supplement contains patent specifications and drawings for a jet-powered rotor helicopter with optional manual or automatic means of changing blade-pitch angle, jet steering, and provision for additional forward thrust. The original booklet of 1947 contains designs for mechanical-powered rotor helicopters with optional manual or automatic means of changing blade pitch angle and with variable speed or variable pitch steering.

SCIENCES, GENERAL

The Centennial of the Sheffield Scientific School. Edited by George A. Baitsell. New Haven, Conn., Yale University Press, 1950. 206 pp., illus. $3.00.

This volume contains four lectures on physics, chemistry, virus research, and genes and biological enigmas, including "High Energy Physics," by Ernest O. Lawrence. Other papers included are a history of the school, biographical notes on Benjamin Silliman, and "Science and the Whole Man," by Edmund W. Sinnott.

CHEMISTRY

Chemical Engineers' Handbook. Edited by John H. Perry. New York, McGraw-Hill Book Company, Inc., 1950. 1,942 pp. $15.

The last revision of this standard handbook appeared in 1941. This edition uses a larger page, permitting the use of larger graphs and charts, and a greatly expanded text with less thickness. There are 30 sections by 141 authorities. Among the sections thoroughly revised are Flow of Fluids, Heat Transmission, Physical and Chemical Data, Mathematics, Mathematical Tables, Weights and Measures, Fuels, Refrigeration, Materials, Accounting, and Cost Finding. A number of other sections and chapters have been rewritten and expanded, and new sections have been added. The chapters, Report Writing and Organic Chemistry, have been deleted. This edition more than meets the high standard set by preceding editions.

MATHEMATICS

Vector and Tensor Analysis. Harry Lass. New York, McGraw-Hill Book Company, Inc., 1950. 347 pp., diagrs. $4.50.

Intended for upper-class and graduate students, this textbook takes up the algebra and calculus of vectors in chapters 1, 2, and 4 and applications in the fields of differential geometry, static and dynamic electricity, mechanics, and hydrodynamics and elasticity in chapters 2, 5, 6, and 7. The final two chapters deal with tensor analysis and Riemannian geometry and their applications. A list of 18 comprehensive treatises is included. Numerous examples are worked out in the text, and problems are given with each section. The author is Assistant Professor of Mathematics at the University of Illinois.

Elements of Analytic Geometry. William L. Hart. Boston, D. C. Heath and Company, 1950. 264 pp. $2.75.

This textbook, designed for college freshmen familiar with college algebra and trigonometry, is intended to present the elements of plane and solid analytic geometry required as preparation for calculus, and applications of analytic geometry in engineering, the physical sciences, and statistics. Explanations of theory are intentionally full, and some material among the exercises and examples and at the ends of chapters is indicated as supplementary. The author is Professor of Mathematics at the University of Minnesota.

MECHANICS

Engineering Mechanics. Archie Higdon and William B. Stiles. New York, Prentice-Hall, Inc., 1949. 505 pp., illus. $6.65.

In this engineering textbook, the emphasis is placed on principles. For example, the algebraic solution rather than the graphic solution of the equations of relative motion is stressed, and graphic methods generally are omitted, since the time required to develop proficiency in them is not felt justified in a basic course. Two chapters on kinematics precede the four chapters on kinetics to provide essential principles, and the concept of relative motion is emphasized as an aid in studying rigid body motion. The authors are Professors at Iowa State College.

Principles of a New Energy Mechanics. Jakob Mandelker. New York, Philosophical Library, 1949. 73 pp., figs. $3.75.

The author's "energy mechanics," which evolved from the same basic relations as Einstein's special theory of relativity, uses a new kinetic energy formula of a definite upper limit, previously unsuspected, which coincides exactly with the value for the radiating energy. The classical mechanics is included as a particular

limiting case. The mechanics as outlined is valid for high velocities, confirms the result of Fizeau's experiment, the Lorentz transition formula, and the dual character of force for rest and for motion. The author is an assistant professor of mechanics at the Georgia School of Technology.

PHYSICS

Dissociation Energies and Spectra of Diatomic Molecules. A. G. Gaydon. New York, Dover Publications, Inc., 1950. 239 pp., illus. $3.95.

The author's purpose is to give a rounded account of the theory of the determination of dissociation energies of diatomic molecules and to summarize the known numerical data. The approach is primarily from the spectroscopic standpoint, with separate chapters on the determination of dissociation energies by thermal methods and by controlled electron impact. Applications of the values for chemically important molecules include estimates of the temperature and amount of dissociation in high temperature reactions, as in combustion and in explosions. Numerical data are collected in the last chapter for about 250 diatomic molecules. A bibliography of 491 references is included. The author is Warren Research Fellow of the Royal Society.

Out of My Later Years. Albert Einstein. New York, Philosophical Library, 1950. 282 pp. $4.75.

Writings by Professor Einstein from 1934 through 1949 are presented in this volume. There are 60 essays in all, on his convictions and beliefs, public affairs, science and life, personalities, Jews, and eight papers (82 pages) on relativity and other aspects of theoretical physics. These include "The Theory of Relativity" (1949), "$E = MC^2$" (1946), "Time, Space, and Gravitation" (1948), "Physics and Reality" (1936) (in six parts), "The Fundamentals of Theoretical Physics" (1940), "The Common Language of Science" (1941), "The Laws of Science and Laws of Ethics" (1950), and "An Elementary Derivation of the Equivalence of Mass and Energy" (1946).

THERMODYNAMICS

Heat Pump Applications. Emory N. Kemler and Sabert Oglesby, Jr. New York, McGraw-Hill Book Company, Inc. 1950. 300 pp., illus., diagrs. $6.00.

Installations of heat pumps in buildings, factories, and dwellings in the U.S. and elsewhere are described, following a general survey of the present and future uses of the heat pump in heating, refrigeration, air conditioning, and in industrial processes. The thermodynamics of the heat pump, including cycles and heat sources, is next discussed, and the final half of the book deals with components, including compressors, fans and ducts, electric motors, heat exchangers, and accessories. The design of heating systems and storage and hot-water units are also discussed, and there is a separate chapter of patent abstracts. Bibliographies are included at the ends of chapters.

Heat Pumps and Thermal Compressors. S. J. Davies. London, Constable and Company, Ltd., 1950. 126 pp., diagrs. 9*s*.

These four lectures, here given in expanded form, were originally presented by Professor Davies at King's College, University of London, to advanced students. Following a general introduction, the discussion takes up heat pumps using vapor compression cycles, conditions determining the performance of heat pumps using gases as the working substance, and the application of heat pumps to air conditioning. Applications of thermal compressors of the piston and turbo types are discussed in the final lecture, including a description of the Philips hot-air engine.

Heat Transfer Lectures. Fairchild Engine and Airplane Corporation. NEPA Heat Transfer Symposium, 1947. Oak Ridge, Tenn., U.S. Atomic Energy Commission, 1949. 2 Vols., 275, 342 pp., diagrs. Vol. 1, $0.90; Vol. 2, $1.00.

Contents. Vol. I: Introduction, J. Carlton Ward, Jr. A Summary of the Elements of Heat Transfer, H. J. Stoever. High Densities of Heat Flux From Metal to Water, William H. McAdams. Calculations of Conduction, G. M. Dusinberre. The Measurement of Rapidly Changing Temperatures, G. A. Hawkins. Prediction of Recovery Factors, Howard W. Emmons. Pressure Drop in Commercial Exchangers, Byron E. Short. Exploding a Heat Transfer Myth, Benjamin Miller. Heat Transfer from Hot Metal to Boiling Water, R. L. Scorah. Heat Transfer Equipment, K. W. Coons. Use of Network Analyzers for Solving Thermal and Stress Problems, F. W. Bubb. Heat Transfer to Granular Materials, R. L. Pigford. Effect of Solar Radiation on a Body at High Altitudes, S. M. Marco. Infrared Radiant Heating, Harold J. Garber.

Vol. II: Gravitational Diffusion from a Boundary Source, Hunter Rouse. Experiments in Heat Transfer to Air in Subsonic and Supersonic Flow, Joseph H. Keenan. The Mechanics and Thermodynamics of One-Dimensional Gas Flow, A. A. Shapiro. Geometrical Problems in Radiant Heat Transfer, H. C. Hottel. The Effect of Vapor Velocity on Condensation Inside Tubes, A. P. Colburn. Thermal Problems in Fixed Bed Continuous Flow Catalytic Converters, R. H. Wilhelm. Thermal Pressure Drop Considerations in Aircraft Heat Exchangers, M. F. Valerino. Heat Transfer to Liquids Boiling Under Pressure, Charles F. Bonilla. Heat Transfer Through Finned Tubes, Donald L. Katz. Heat Resisting Alloys, J. W. Freeman. Heat Transfer to Oils in Tubular Exchangers, O. P. Bergelin. Heat Transfer in Recirculating Atmosphere Furnaces, C. A. Siebert. Fundamental Heat Transfer Considerations with Illustrations, L. M. K. Boelter. Heat Transfer to Molten Metals, R. C. Martinelli. Shell Side Heat Transfer Characteristics of Segmentally Baffled Shell and Tube Heat Exchangers, Townsend Tinker.

Special I.A.S. Publications

Sherman M. Fairchild Publication Fund Papers

No.		Member Price	Nonmember Price
FF-2	A Study of the Flow, Pressures, and Loads Pertaining to Prismatic Vee-Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
FF-1	Ice Protection for Turbojet Transport Airplane (In Three Parts)—P. T. Hacker, R. G. Dorsch, T. F. Gelder, J. P. Lewis, H. C. Chandler, Jr., and S. L. Koutz.	$0.75	$1.25
286	Linearized Treatment of Supersonic Flow Through Axi-Symmetric Ducts with Prescribed Wall Contours—Charles E. Mack, Jr., and Ignace I. Kolodner.	$0.75	$1.25
244	Wetted Area and Center of Pressure of Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$0.75	$1.00
229	Wave Profile of a Vee-Planing Surface, Including Test Data on a 300 Deadrise Surface—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
170	Wave Contours in the Wake of a 10° Deadrise Planing Surface—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
169	The Discontinuous Fluid Flow Past an Immersed Wedge—Experimental Towing Tank, Stevens Institute of Technology.	$0.75	$1.00
168	Wave Contours in the Wake of a 200 Deadrise Planing Surface—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
167	On the Pressure Distribution for a Wedge Penetrating a Fluid Surface—Experimental Towing Tank, Stevens Institute of Technology.	$0.75	$1.00
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101	Introduction to Shock Wave Theory—J. G. Coffin.	$2.65	$3.50
100	Blade Pitching Moments of a Two Bladed Rotor—R. W. Allen	$0.75	$1.00
126	External Sound Levels of Aircraft—R. L. Field, T. M. Edwards, Pell Kangas, and G. L. Pigman	$0.75	$1.00

Corporate Member News

(*Continued from page 12*)

test chamber of Aircraft Gas Turbine Division, a water-cooled 12-ft. periscope allows engineers to watch the pattern of burning gases in the 2,500° exhaust blast of a jet engine. Image of the burning gases is transmitted through the 500-lb. steel cylinder to observers by means of a conventional optical system. On the viewers' end of the periscope are a 16-mm. motion-picture camera, an observer's eyepiece, and a large television-like screen that several persons may watch. . .Tooling for additional production of B-47 swept-wing Stratojet bombers is now under way at Wichita Division, Boeing Airplane Company, following a U.S.A.F. order for "substantial" additional numbers of the aircraft. The plane is to be equipped with six J-47 turbojet engines of more than 5,200-lb. thrust each, manufactured by the Aircraft Gas Turbine Division, General Electric Company.

• Grumman Report. . .With the 1949 gross sales amounting to $59,756,838 and net earnings for the same period at $3,191,-520, **Grumman Aircraft Engineering Corporation** declared dividends totaling $2.00 per share to stockholders during its 20th year of operations.

• Backlog. . .**Lear, Incorporated,** announces a backlog of unfilled orders as of the end of April amounting to $9,600,000.

• Supply Pod. . .**Lockheed Aircraft Corporation** has redesigned and enlarged its Speedpak under-fuselage pod.

• Target Drones. . .The delivery of the first two KDM-1 pilotless target drones to the Naval Air Development Center, Johnsville, Pa., was announced by **The Glenn L. Martin Company.** Soon to be subjected to the latest fire-control systems of the Fleet, the KDM-1's, which fly with the speed of a jet fighter plane and have a 10-ft. wing span, are suspended on a pylon near the wing tip and are taken aloft by a mother ship. When proper launching speed and altitude are reached, the Marquardt ram-jet engine on the KDM-1 is started, and the target drone is released from the pylon. From then on it is controlled from afar entirely by radio while being watched on a radar screen. Engine speed is controlled with drag brakes to maintain desired subsonic speeds during firing tests. . .The Martin XB-51, a ground support bomber, has completed the first phase of flight testing and has commenced the second. The XB-51 is the first bomber to use the variable incidence wing. Powered with three General Electric J-47 engines with over 5,200-lb. thrust each, the plane has flown at speeds higher than any other bomber of its type.

• Dividend. . .**Minneapolis-Honeywell Regulator Company** has declared an initial quarterly dividend of 40 cents a share on the new $1.50 par common stock, payable June 10 to stockholders of record May 25.

• Texan Trainers. . .**North American Aviation, Inc.,** has received an order from the Mexican Air Force for 20 additional remanufactured T-6 Texan trainers. . . First production T-28 trainer produced by North American is undergoing accelerated service testing, following an Air Force acceptance flight.

• New Flight Testing Area. . .**Northrop Aircraft, Inc.,** has entered into a long-term agreement for lease of facilities at Ontario International Airport for use in production testing of the Air Force's new Northrop Scorpion F-89 all-weather interceptor. The company will acquire use of a large hangar, office, and engine test and ground-firing test facilities.

• Net Earnings. . .**Pan American World Airways System** reports estimated 1949 net earnings as $2,489,000 after taxes. The dividend paid per share was 25 cents.

• Taxi Tests. . .Taxi tests have been completed on the YF-96A, a new swept-wing version of the F-84 Thunderjet fighter-bomber. Manufactured by **Republic Aviation Corporation,** the fighter is powered with an Allison J-35 turbojet engine.

• Pressurization Units. . .**Stratos Corporation,** Farmingdale, N.Y., a subsidiary of Fairchild Engine and Airplane Corporation, has received a $250,000 order from Pan American World Airways System for cabin pressurization units, Model S60, with delivery to begin in the summer.

• Completes First Tests. . .A new Navy swept-wing jet fighter, XF7U-1, designed for shipboard operation, has successfully completed its initial flight tests at the Naval Air Test Center, Patuxent River, Md. Manufactured by the Chance Vought Aircraft Division, **United Aircraft Corporation,** the XF7U-1 is in reality a tailless flying wing and is powered with Westinghouse turbojets. It is rated in the "over-600-m.p.h. class." To achieve the relatively low speeds necessary for landing aboard carriers, the plane is equipped with leading-edge slats. Speed brakes are located at the trailing edge of the wings. . . Hamilton Standard Division, United Aircraft Corporation, is producing 100 7-ft. fan blades, approximately 22 ft. in diameter, for wind tunnels at the Cornell Aeronautical Laboratory, Inc., Buffalo, and the Southern California Cooperative Wind Tunnel, Pasadena. Fans, consisting of 16 blades mounted in hubs with a 10-ft. diameter, will be used to create airflows up to 900 m.p.h. for aerodynamic research.

• Regulator. . .A new-type carbon pile voltage regulator, Type AVR-89, produced by **Westinghouse Electric Corporation,** will maintain a constant voltage output on a 30-volt, 100- to 400-amp. d.c. aircraft generator over its range of speed and load. It weighs 2.75 lbs.

I.A.S. Sections

Buffalo Section

R. Allen Price, *Secretary*

Captain Vincent Mazza, who was introduced by Lt. Col. H. M. Sweeney, was the speaker at the March 15 Section meeting. In his lecture Captain Mazza described the history of the ejection seats and the effect of high-speed air blast and the functions of the various automatic devices for opening of chutes.

Films were shown which had been produced for indoctrination in the use of ejection seats and which included high-speed pictures taken during Captain Mazza's own voluntary ejections at air speeds up to 550 m.p.h.

On April 12, a joint meeting was held with the American Helicopter Society at the Westbrook Hotel. Captain Robert A. Strieby, U.S.M.C., Rotary Wing Branch, U.S. Navy Bureau of Aeronautics, spoke on the "Use of Helicopters for Troop Carrying by the U.S. Marines." Chairman Robert Kluge led the meeting, attended by 130 persons.

Captain Strieby described the efforts of the U.S.M.C. to utilize helicopters for troop-carrying and assault. The Piasecki HPR-1 helicopter has been used in these operations and the Sikorsky HO3S-1 for liaison and rescue. Captain Strieby stated that helicopters may be successfully employed to put troops on enemy-held beaches with a considerable saving of life and equipment. A motion picture was shown which depicted a typical operation from a CVE carrier, where eight helicopters each brought in eight troopers and then returned to the carrier to pick up artillery, which was then flown into the beach.

Chicago Section

Alfred F. Stott, *Secretary*

On April 18, a joint meeting with the American Society of Mechanical Engineers was held in the Auditorium of the Western Society of Engineers. C. D. Miller, Research Engineer, Battelle Memorial Institute, spoke on the "Combustion Processes and Shock Waves in Gasoline Engines."

▸ **High-Speed Camera**—Mr. Miller described the development of the camera used for high-speed photography and outlined the differences between those taking 40,000 frames per sec. with the modern ones taking 200,000 frames per sec. The talk was illustrated with a set of slides showing the principle of operation of the camera and the rotating prisms with the reflecting system. Mr. Miller also presented a film that clearly pictured flame propagation inside the cylinder, as well as the burning of various fuel-air ratio mixtures, includ-

High-Speed Refrigeration Turbine Wheel

This is a photomicrograph, at high magnification, of a fatigue crack which developed in a turbine wheel during laboratory overspeed test. Failure of vital components of jet airplanes traveling faster than the speed of sound cannot be tolerated.

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Important member of the Lockheed jet family is the two-place T-33 Jet Trainer (shown here), only jet trainer airplane built in America today (Navy designation: TO-2). This dual-control fighter-trainer now trains the pilots for the supersonic fighter planes of the Army, the Navy and the Marine Corps.

The experience obtained in the design, development and manufacture of jet fighter planes is invaluable in the Lockheed laboratories where the designs of the future are taking shape today.

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Aircraft Corporation, Burbank, California

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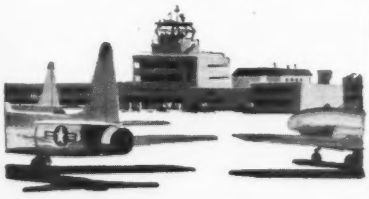

ing those mixtures in which detonation was present.

Dayton Section

Robert W. Hoeflein, *Secretary*

Chairman A. F. Arcier conducted the meeting of February 28 at the Biltmore Hotel at which the speaker was A. H. Sullivan, Jr., Electrical Engineer, Electronics Section, Technical Analysis Division, A.M.C., Wright-Patterson Air Force Base. The title of his paper was "Current Problems in Aircraft Radio."

▸ **Basic Problems**—The basic problems of aircraft radio are: (1) the obtaining of accurate and intelligible information about conditions internal and external to the aircraft; (2) the analysis and digestion of this information; and (3) use of the information in controlling the aircraft. Among the problems covered by Mr. Sullivan were the necessity of aircraft flush-mounted antennas, radio and radar equipment vs. aircraft weight and space, and the assignment of operating frequencies. Mr. Sullivan referred to plan SC-31, conceived by the Radio Technical Commission for Aeronautics, which is scheduled for completion by 1963. This program, he said, will utilize the systems of omnirange, distance-measuring, course-line computing, ground-controlled approach, and instrument landing to control automatic flight. Mr. Sullivan stated that the ultimate goal of aviation in the not-too-distant future is to complete automatic flight.

Morton Brooks, Supervisor, Technical Analysis Section, Aeroproducts Division, General Motors Corporation, spoke to the 60 attending members at the March 28 meeting at the Hotel Biltmore. Chairman A. F. Arcier presided.

▸ **Turboprops**—In his illustrated talk on the "Applications of Turboprops to Future Aircraft," Mr. Brooks established the following points as being characteristic: (1) The turboprop-powered aircraft shows a definite advantage over all other current means of propulsion where long range at high speed and good take-off characteristics are required; (2) the old propeller requirements of safety and dependability must be retained in the turboprop system along with all the additional complications of the turbine-powered system; (3) as compared to conventional propeller systems, the turboprop system with its added complexity must demand maximum coordination between propeller turbine and fuel system (to date the most satisfactory method of obtaining

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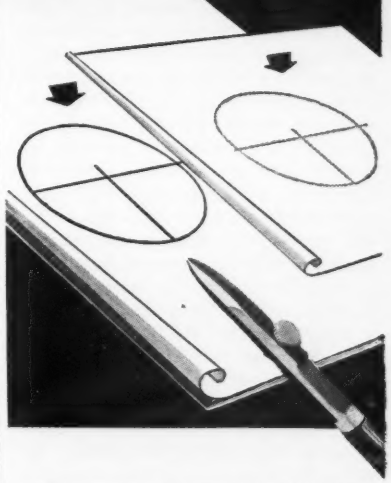

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this precise control is through electronic means); and (4) it is indicated that simplification and some degree of standardization will result as experience with current turboprop installations increases.

▶ **Military Preparedness**—At the April 25 meeting Dr. Albert E. Lombard, Jr., F.I.A.S., Scientific Advisor, Research and Development Directorate, Department of the Air Force, spoke on "Military Preparedness and Research." Chairman Arcier led the meeting.

Dr. Lombard stated that until such a time as world peace becomes a "matter of policy," "the United States must . . . be armed with sufficient military power either to persuade any aggressor nation of the fruitlessness of starting a war or to stave off any initial attack of an aggressor nation and go on to win the military engagement . . . "Preparedness," he went on to say, "must involve a state of readiness for participation in constructive activities of benefit to mankind," as well as "participation in destructive warfare when all other means have appeared to fail." In stressing the consequent need for a strong support of basic research, Dr. Lombard outlined the work carried on by the Air Force's Office of Air Research in Dayton and concluded his talk by emphasizing the importance of the individual in research. "Progress comes," he declared, "when individuals conceive of new ideas, explore them, and publish the results."

Detroit Section

Joseph Rutkowski, *Secretary*

A meeting was held on March 2 at the Engineering Society of Detroit Building. The presiding officer was Chairman L. Patrick. Joseph Rutkowski, M.I.A.S., Professor, Wayne University, and Aero Research Center, University of Michigan, spoke on "Optical Methods for Flow Observation." Forty members attended.

Professor Rutkowski discussed basic and general principles of optical methods for measurements. He also described the shadowgraph, schlieren, and interferometric methods. The lecture was illustrated by slides and accompanied by two short films that showed the shadowgraph of confined combustion and an interferometric study of transition.

Hagerstown Section

Logan T. Waterman, *Secretary*

The February 28 meeting was held in the Loyal Order of Moose Hall with Chairman D. W. Weller presiding. A symposium on aircraft supercharging and heating was conducted with J. Wright, AiResearch Manufacturing Company, F. Scott, Surface Combustion Corporation, and Richard Lodge, Minneapolis-Honeywell Regulator Company, as the speakers.

Mr. Wright described and illustrated with slides the various methods now in use for cabin supercharging, air exchanging, and cooling with compressors, intercoolers, and expansion turbines.

Mr. Scott described and illustrated with slides the "Surface Combustion" cabin and anti-icing air heater.

Mr. Lodge explained the principles, problems, and practices in regulation of cabin air supply.

Los Angeles Section

Harrison A. Storms, *Secretary*

A cruise, which was attended by 218 members, was made on February 7 on the Carrier, U.S.S. "Valley Forge" (CV-45) in company with the Destroyer, DD-870, acting as plane guard. The success of the trip was assured by the hearty reception and efficient organization, due in a measure to the efforts of Capt. H. B. Temple and his Executive Officer, Cmdr. R. P. Beebe.

▶ **Bounce Drill**—After a welcoming address by the Carrier Skipper, Captain Temple, small groups of members were escorted throughout the ship by ship's officers. Following these tours, 14 Vought Corsair (F4U) fighter planes demonstrated a "bounce" drill, which consisted of successive landings and take-offs from the carrier. A helicopter flying overhead acted as an additional plane guard. Six F9F Grumman Panther carrier-based jet fighters, which joined the Corsairs, were retrieved aboard and then were immediately catapulted off.

▶ **The Strike**—In the afternoon 16 Corsairs and six Grumman Panthers rendezvoused and gave a firing demonstration, the target being carried astern the carrier on a cable of about 1,500-ft. length. As the ship headed back to Long Beach harbor, guided tours were again undertaken, and the day ended with the I.A.S. members deeply appreciative of the hospitality and courtesy shown by the Officers and men of the U.S.S. "Valley Forge."

New York Section

C. E. Pappas, *Secretary-Treasurer*

Under the Vice-Chairmanship of R. Dixon Speas, in the absence of Chairman E. M. Lester, the Section heard, on February 16, G. W. Brady, Chief Engineer, Curtiss-Wright Corporation, Propeller Division; C. M. Kearns, Engineering Manager, Hamilton Standard Division, United Aircraft Corporation; and R. C. Tresider, Chief Engineer, Aero Products Division, General Motors Corporation, on the subject of "Turboprop Trends."

A complete discussion of propellers for turboprop engines for military and transport airplanes was given. The discussion covered the performance, design, and operational characteristics of single- and dual-rotation propellers for the subsonic, transonic, and supersonic speed ranges. It was revealed that propellers can be made to operate efficiently at speeds up to and beyond that of sound. It was also pointed out that the most successful blade type has been the square-tipped rectangular-shaped plan form. Sweepback of propeller blades proved of little value. The work on high-speed propellers has been primarily concentrated on development of a blade thin enough to operate efficiently at high speeds but strong enough to withstand vibrations and stresses. As pointed out by Mr. Kearns, "We have serious development problems in making such a propeller structurally sound, but the indicated improvements in airplane performance at speeds up to and including that of sound are sufficient to warrant a major development effort."

On March 16 an all-day session was held on "High-Speed Flight Phenomena." The March meeting of the Section was held jointly with the Metropolitan Section of the S.A.E. and was devoted to discussions on high-speed flight phenomena by representatives of both manufacturers and the Services.

Cochairmen of the morning and afternoon sessions were: Gordon McKinney, Assistant Sales Manager, Propeller Division, Curtiss-Wright Corporation, and C. E. Pappas, Chief of Aerodynamics, Republic Aviation Corporation. Philip B. Taylor, of Sanderson and Porter, was Technical Chairman of the evening session. Speakers at the morning session were W. Vincent Hurley, Aircraft Gas Turbine Division, General Electric Company; Joseph Flatt, Air Materiel Command, U.S.A.F.; and C. E. Pappas. Speakers at the afternoon session were Vern Outman, McDonnell Aircraft Corporation; Robert Liddell, Republic Aviation Corporation; and A. A. Redding, Westinghouse Electric Corporation.

The meeting was held at the Hotel Statler in New York City. The papers covered trim changes occurring at high Mach Numbers, buffeting, elevator effectiveness, and roll-off characteristics. The advisability of using an adjustable stabilizer as a maneuvering device was also discussed. A lively discussion took place on the problem of proper control-

stick-force variation versus Mach Number.

The success of the evening forum discussion was amply demonstrated by the continuous barrage of questions that came from the floor.

Under the Chairmanship of E. M. Lester, the Section heard, on April 20, Christopher Clarkson, Civil Air Attaché, British Embassy, on the subject of "British Air Transport Developments." Mr. Clarkson gave an interesting talk on the trends in British air transport design and also his views and thoughts on air transportation. The speaker reviewed the general characteristics of some of the latest British transports, including the Barbazon, Princess, Comet, Viscount, Apollo, Hermes, Heron, Prince, Dove, and Sealand.

The talk was concluded with the showing of an interesting film illustrating the latest British designs, both military and commercial.

On May 11, "The Air Engineering Development Center" was the subject of talks by Major Gen. F. O. Carroll, U.S.A.F., Assistant Deputy Chief of Staff for Materiel, and John W. Crowley, Associate Director of Research, N.A.C.A. E. M. Lester, Chairman, presided at the meeting attended by 250 members.

General Carroll spoke on the technical phases, the objectives, the overall organization, and the operating policies of the Air Engineering Development Center. A brief description of the proposed arrangement and location of a Test Center was given. The General spoke on an Interim Plan and an Overall Plan commonly known as the Unitary Wind-Tunnel Plan. The Interim Plan will consist of three wind tunnels. One tunnel would be used for testing engines at various Mach Numbers extending into the supersonic range under varying altitude conditions. The second tunnel would be a large supersonic tunnel for testing and evaluating various aircraft models. The third tunnel would be a hypersonic tunnel operating at Mach Numbers of 6 to 10. A discussion was given on the Unitary Wind-Tunnel Plan, which embraces test facilities to be established at various universities, at the A.E.D.C., and at Ames and Langley Aeronautical laboratories.

Mr. Crowley was Guest Speaker at this meeting and spoke on the association that the N.A.C.A. would have with the Air Engineering Development Center. He pointed out the complex problems, both scientific and financial, of setting up such an organization. He also spoke on the facilities that would be made available and the manner in which these facilities would be used by the Services, the N.A.C.A., and the industry.

Ottawa Section

J. C. Finlayson, *Secretary-Treasurer*

The Ottawa Aeronautical Society is composed of members of the Institute of Aeronautical Sciences, the Royal Aeronautical Society, and the Engineering Institute of Canada.

The March 21 meeting, with Air Marshal G. O. Johnson in the chair, was held in the auditorium of the National Research Council. Forty-five members turned out to hear Basil Rabnett, Manager, Aviation Division, Shell Oil Company of Canada. deliver a talk on "Recent Developments in Aviation Fuels."

▶ **Fuels**—Mr. Rabnett traced the history of the development of high-octane aviation fuel and discussed the various qualities which a fuel must possess and the effect on engine performance of variations in each quality. Before closing his lecture, he briefly discussed fuels for gas-turbine engines, pointing out that turbine-engine development arising from improvements in fuels would not be nearly so great as that demonstrated by the piston engine.

▶ **Films**—Two motion pictures were shown, the first a Shell Oil Company film dealing with the S.B.A.C. Flying Display at Farnborough in September, 1949, and the second a short U.S.A.F. film entitled *Aeronautical Oddities.*

▶ **Induced Precipitation**—The meeting of April 24 was held in the auditorium of the National Research Council with Air Marshal Johnson presiding. J. L. Orr, Head of the National Research Council's Low Temperature Laboratory, presented a paper on "Induced Precipitation," in which he described work that had been done on this project in Canada up to the present time. He indicated that, while the results so far obtained were interesting, a great deal still remained to be discovered before "deserts could be transformed into jungles."

San Diego Section

Leon R. Wosika, *Secretary*

Dr. Ralph E. Gibson, Director, Applied Physics Laboratory, The Johns Hopkins University, spoke on "Supersonic Guided Missiles" before an audience of the 190 members attending the February 23 meeting.

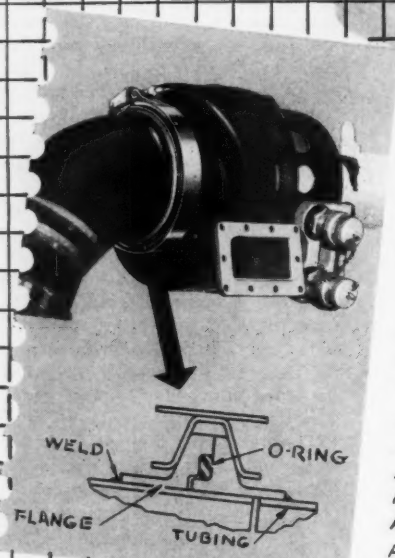
▶ **Guided Missiles**—Dr. Gibson stated that the guided missile "is a modern answer to the problem that has confronted designers of weapons throughout the years—how can we increase range, speed, maneuverability, accuracy, and damage potential without losing reliability or incurring too great a cost."

As "pilots must rely increasingly on ground-controlled automatic devices to enable them to find and attack their targets," Dr. Gibson stated that "the logical conclusion was complete replacement of the pilot by mechanical devices." He described the characteristics that such a missile must possess and outlined the various guidance systems. He also spoke of propulsion methods, such as rockets and ram-jets, as well as their advantages and disadvantages. Dr. Gibson noted, however, that, while advances had been made, many and complex questions remain unanswered. In conclusion, he quoted from Dr. Vannevar Bush's recent book *Modern Arms and Free Men,* in which it is stated that "Its [guided missiles'] significance lies in the fact that it appears to be the great future enemy of the bomber, and it may in time turn the tide that began to flow at Kitty Hawk in 1903 and that reached its crest in the bomber fleets that darkened the skies of the last war. . . . The days of mass bombing may be thus approaching their end. If so, it is a good thing for the world." A film on the V-2 rocket was shown.

▶ **Forum**—On March 16 the topic of a forum meeting was "Hydraulics vs. Pneumatics vs. Electrical Systems." With Ralph L. Bayless, A.F.I.A.S., Chief of Preliminary Design, Consolidated Vultee Aircraft Corporation, as moderator, the panel consisted of the following speakers from Consolidated Vultee Aircraft Corporation and General Electric Company: For Electrical: Paul Ferrara, Design Group Engineer, Convair; P. E. Humphrey, Design Specialist, Convair; and George Allamassy, Specialist on Aircraft Electrical Systems, G-E. For Pneumatic: J. H. Famme, Project Engineer, XP5Y, Convair; and H. F. Gerwig, Engineering Designer, Convair. For Hydraulic: G. A. Lemke, Design Specialist, Convair; and J. M. Hudson, Engineering Designer, Convair.

▶ **Conclusions**—After the presentation, rebuttal, and discussion, it was generally concluded that the particular airplane and the particular problem involved determined which system should be employed from a consideration of reliability, safety, temperature, time of actuation, rigidity, weight, and serviceability. It was also conceded that, from a weight standpoint, the muscles in an electrical system (i.e., motors, solenoids, and actuators of high horsepower) were considerably heavier than their brothers in other categories for doing an identical job. The pneumatic system, for example, offers extreme

ENGINEERS NOTEBOOK



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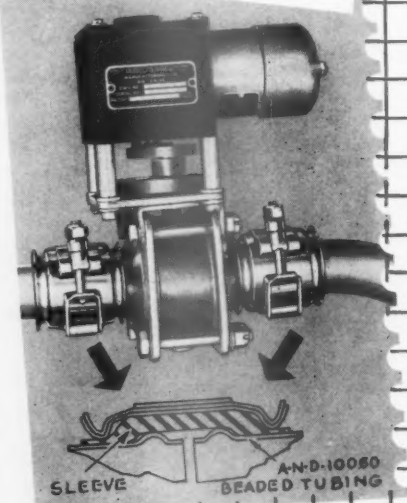

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independence for an aircraft that must patrol an area a long distance from its base, where the use of an electrical system would require a battery or A.P.U. too heavy to carry along whereas a G.T.C. unit is adequate from a power-weight standpoint.

Texas Section

David L. Mellen, *Secretary*

William C. Keller, M.I.A.S., Project Engineer, Consolidated Vultee Aircraft Corporation, was the speaker at the March 22 meeting held in the American Legion Hall, Grand Prairie, Tex. Chairman Russell J. McCrea led the meeting; 170 persons attended.

▸ **Propeller Turbines**—Mr. Keller pointed out in his speech on "Propeller Turbines in Transport Aircraft" that Convair conducted the world's first flight with such power plants. He stated that demands for improved economic and aerodynamic performance in commercial transport aircraft caused Convair to instigate a study of turbine-powered air-frame design relative to air-line economics, with the conclusion that adaptation of propeller turbines to existing modern air-frame designs is the next most logical step. Mr. Keller went on to say that the increased performance expected through use of these engines should yield tremendous impetus to the design of water-borne military aircraft. His talk was a preview of one presented at the I.A.S. Fifth Annual Flight Propulsion Meeting held on March 24 at the Hotel Carter, Cleveland, and which will appear in full in a forthcoming issue of the REVIEW.

Toronto Section

H. C. Luttman, *Secretary*

A joint meeting with the Toronto Gliding Club was held on April 20 in the New Mechanical Building at the University of Toronto. An illustrated lecture was given by P. D. McTaggert-Cowan, Assistant Controller, Meteorological Division, Department of Transportation, Canada, who spoke on "Meteorological Problems of High-Speed and High-Altitude Flight." Chairman C. V. Lindow was the presiding officer; approximately 65 persons attended.

▸ **Jet Streams**—Defining high altitude as 20,000 to 100,000 ft. and high speed as that speed up to, but not including, sonic velocity, Mr. McTaggert-Cowan pointed out that the four principal characteristics of the atmosphere of interest to aviation were temperature, humidity, wind, and

turbulence. In speaking of the wind pattern, he referred to "jet streams," a phenomenon occurring anywhere from 15,000 ft. to 50,000 ft. in the northern hemisphere. Likely to be of considerable importance to jet-powered aircraft, these jet streams were compared to high-speed rivers, meandering in three directions. The speaker felt that these streams, which are found between latitudes 30° and 70° North, would interfere seriously with direct westerly Atlantic crossings by high-altitude aircraft.

Student Branches

Polytechnic Institute of Brooklyn

A joint meeting and field trip of the I.A.S. Student Branches of the New York Metropolitan area were held at the Polytechnic Institute of Brooklyn on March 28. With the faculty and students of the Brooklyn Polytech acting as hosts, 16 guests from the Stewart Technical School, 18 from the Academy of Aeronautics, and 40 from the Polytechnic Institute of Brooklyn participated.

During the morning session, Herbert O. Fischer, Chief Test Pilot, Curtiss-Wright Corporation, spoke on "Flight Tests of Reversible Propellers," in which he discussed the development of propeller reversing mechanisms and the tests that Curtiss-Wright had conducted on aircraft in flight. Mr. Fischer disclosed that flight tests on the B-36 with full reversal would begin in about 5 months. His lecture was amplified by a film that showed tests on a C-54 equipped with four electronic governors that permitted constant speed in either forward or reverse angles of attack.

Later in the day, a guided tour through the facilities at the Polytechnic Institute was offered. Explanatory lectures of the equipment being viewed were given by Vito L. Salerno, M.I.A.S., Assistant Professor of Applied Mechanics; Dr. Nicholas J. Hoff, A.F.I.A.S., Professor of Aeronautical Engineering; Dr. Sebastian V. Nardo, T.M.I.A.S., Instructor in Aeronautical Engineering; S. Bernstein; Robert Sauer; Lawrence Kaufman; J. Sano; J. McElroy; and Burton Erickson.

After the tour the combined membership assembled to hear Howard Reiss present a paper entitled, "An Introduction to Supersonic Aerodynamics." Ralph Lesley, Vice-Chairman, Student Branch, Polytechnic Institute of Brooklyn, discussed the "Use of Birefringent Fluids in Investigating Shear Flow." Chairman Lawrence Kaufman presided.

Brown University

On March 28, Gerald Gill, who is associated with the Massachusetts Institute of Technology Diffusion Project, lectured on the establishment of weather observation stations in northern Canada and in the Arctic regions. Chairman Rodger B. Dowdell presided.

Catholic University

On April 19, 35 persons heard Dr. Max Munk, Special Lecturer, Catholic University, and Consultant, Naval Ordnance Laboratory, present a talk on "The Development and Use of the Flex-O-Prop." Dr. Munk outlined the steps leading to the development of the Flex-O-Prop, which was patented in October, 1949. Chairman Woodrow Seamone presided.

University of Colorado

On March 2, R. D. MacDonald, District Airport Engineer, C.A.A., in charge of Building and Construction of Airports in the Denver Area, spoke on "Airport Construction and Planning." Chairman Robert Fischer presided.

University of Florida

At the meeting of March 14 led by Chairman Charles E. Jordan, the following officers were elected: Chairman, E. C. Allison; Vice-Chairman, C. Francisco; Treasurer, L. R. Trotter; Recording Secretary, J. P. Trebes; and Corresponding Secretary, Mona Ferguson.

Howard Piper, Vice-President in Charge of Sales, Piper Aircraft Corporation, spoke on the general aspects of "The Light Plane Industry" at the March 21 meeting. Chairman Edward C. Allison presided.

On April 18, Dr. D. C. Swanson, Professor of Physics, University of Florida, presented a talk and demonstration on "Atomic Energy." Chairman Allison presided.

Massachusetts Institute of Technology

On March 14, two films were shown to the 54 persons present. They included a Northrop Aircraft, Inc., release, *Miscellaneous Views of Flying Wings*, and a Navy film, *Operation Crossroads*. Chairman Henry R. Jex presided.

University of Minnesota

A film demonstrating the *Supersonic Wind Tunnel Facilities at the University of Minnesota* opened the meeting of February 14, presided over by Chairman Alvin D. Riedler. The three speakers of the evening presented talks on various aspects of the wind tunnels.

The first speaker, J. W. Braithwaite, Assistant Professor, University of Minnesota, described the hypersonic intermittent-type tunnel and discussed the thermodynamic properties of air and the measurement of the speed of sound under low pressure and temperature conditions. Kenneth G. Anderson, Lecturer, University of Minnesota, outlined six test facilities that included a transonic and a supersonic tunnel. Frank D. Werner, Lecturer, University of Minnesota, discussed the application of electronics to wind-tunnel research.

After a question-and-answer period, Prof. J. D. Akerman, Head, Department of Aeronautical Engineering, spoke briefly on the development of the Rosemount project.

Northrop Aeronautical Institute

An inspection of the Lynwood, Calif., plant of the Western Gear Works took place on March 10. The value of the tour was heightened by the company guides who gave instructive and interesting discussions of various aspects of the manufacturing process.

University of Notre Dame

On February 15, Chairman Robert Kraemer presided over the meeting at which a color motion picture, *The Bell XP-59*, was shown.

University of Oklahoma

Chairman Robert L. Dickinson presided at the meeting of March 9, at which time a film *Structures*, distributed by North American Aviation, Inc., was shown. Curtis L. Walker, a Student Member, spoke on "Ceramics for Turbojet Buckets."

Student Members Hairston Worstell and David P. Chapell were the speakers at the April 20 meeting led by Chairman Robert L. Dickinson. Mr. Worstell spoke on the problems encountered in the installation of an Allison engine as a source of power in the Oklahoma wind tunnel. Mr. Chapell presented a talk on the balance system of the tunnel.

Oregon State College

A film, *Structures*, released by North American Aviation, Inc., was shown on

March 1. Chairman Elliott R. Buxton presided.

Parks College of Aeronautical Technology

On March 9, the following officers were elected: Chairman, Wallace Carr; Vice-Chairman, Joe Eisley; Treasurer, Robert Kananen; Recording Secretary, David Beyer; and Corresponding Secretary, Aimo Pitkanen. After the election three films were shown. Two of them, *Flight Log* and *Crude Oil Distillation*, were from Shell Oil Company, Inc., while *Double-Decked Clipper* was presented through Pan American World Airways System.

The Pennsylvania State College

On March 15, David J. Gildea, T.M.I.A.S., Associate Professor, Aeronautical Engineering, The Pennsylvania State College, presented a talk on "Preliminary Jet Airliner Design." The meeting was attended by 45 and was presided over by Chairman William Meholick.

Rensselaer Polytechnic Institute

On March 15, Dr. Paul E. Hemke, A.F.I.A.S., Dean of Faculty and Head, Aeronautical Department, Rensselaer Polytechnic Institute, was presented as speaker of the evening by the Honorary Chairman, Andrew J. Fairbanks, A.F.I.A.S., Professor of Aeronautical Engineering at Rensselaer. Dr. Hemke presented a lecture on "Experiences of Your Flying Dean." Chairman Samuel MacAlees presided over the meeting, which was attended by 47 persons.

Fifty persons attended the April 19 meeting to hear Dr. William R. Hawthorne, M.I.A.S., Department of Mechanical Engineering, Massachusetts Institute of Technology, speak on the "Aircraft Gas Turbines." Chairman Samuel MacAlees presided. Dr. Hawthorne lectured on the problems of development, the parts of a gas turbine, and the three types of engines currently in use—i.e., the reciprocating, the jet or turbojet, and the turboprop.

The following officers were elected: Chairman, Duncan W. Simpson; Vice-Chairman, George R. Vrablik; Secretary-Treasurer, Edward M. Allen; and Assistant Secretary-Treasurer, George C. Gatje.

Stewart Technical School

At the meeting of March 8, the following officers were elected: Chairman, George Jacobs; Vice-Chairman, Guido J. Piediscalizi; and Secretary-Treasurer, Stanley Okarma.

Karl H. Jurgensen, Student Member, gave a talk on "Cross-Wind Landing Gears vs. Airports Present and Future" at the March 22 meeting. Chairman George Jacobs presided at the meeting attended by 18 members.

Syracuse University

On March 16, Martin E. Barzelay, M.I.A.S., Associate Professor of Aeronautical Engineering, College of Applied Science, Syracuse University, spoke on "Transient Heat Flow in Aircraft Structures."

The following officers were elected: Chairman, Edward Stannard; Vice-Chairman, George Schnanke; Secretary, Russell H. Smith; and Treasurer, Hal Stewart.

University of Tulsa

On March 16, lectures were given by three Student Members. John Beadling spoke on "Problems of High Speed Propulsion," Kenneth Murty on "Jet Airliner Design," and Earl Lauer on "Comparison of Engine Types." Motion pictures were shown which included a C.A.A. film on *Theory of Flight*, a U.S.A.F. training film on *Propeller Principles*, and an Aerojet Engineering Corporation release on *Jato Flight Tests*. Chairman Kenneth E. Murty presided.

Virginia Polytechnic Institute

On February 14, an election was held which resulted in the following members being named: Chairman, James C. Williams; Vice-Chairman, David Bevan; Secretary, Charles I. Tynan; and Treasurer, Jeffrey S. Deutsch. After the election, a film on the *V-2 Rocket* was shown.

University of Virginia

A talk, "Explosive Decompression," was given on March 10 by Dr. E. L. Corey, Professor of Physiology, Department of Medicine, University of Virginia. Chairman Robert J. Tapscott presided.

University of Washington

Robert L. Nuber, Project Engineer, Washington State Aeronautics Commission, gave a lecture at the February 2 meeting on the "Activities of the Washington State Aeronautics Commission." Chairman Arthur D. Reynolds presided.

Members on the Move

This new section has been instituted to give information on latest affiliations of I.A.S. Members. All members are urged to notify the News Editor of changes as soon as they occur.

H. Neil Arthur, T.M.I.A.S., Junior Engineer, Wright Aeronautical Corporation. Formerly, Engine and Component Tester, Ranger Aircraft Engines Division, Fairchild Engine and Airplane Corporation.

Wayne D. Cannon, M.I.A.S., European Sales Staff, Lockheed Aircraft Corporation, Geneva, Switzerland. Formerly, Wright Aeronautical Corporation.

Major William S. Dawson, A.M.I.A.S., Weather Communications Officer to Headquarters, 1808th Airways and Air Communications Service Wing, Tokyo, Japan. Formerly, Facsimile Project Officer, A.A.-C.S., Washington, D.C.

Rosella K. Fenton (nee Katz), T.M.I.-A.S., Research Assistant, University of Michigan Aeronautical Research Center. Formerly, Aeronautical Engineer, Wright-Patterson Air Force Base, Dayton Ohio.

Dr. Hans R. Friedrich, M.I.A.S., Ordnance Guided Missile Center, Redstone Arsenal, Huntsville, Ala. Formerly, Fort Bliss, Tex.

Shukry Kamel Ibrahim, M.I.A.S., Pyramids Road, Nessim Station, Giza, Egypt. Formerly, Aeronautics Section, City and Guilds College, South Kensington, London, England.

Karlis Irbitis, M.I.A.S., Chief Designer, Canadian Armature Works, Montreal, Quebec, Canada.

George P. Knapp, M.I.A.S., Chief Engineer, Servomechanisms, Inc. Formerly, Propeller Division, Curtiss-Wright Corporation.

Dr. Alexander M. Lippisch, M.I.A.S., Research Engineer, Collins Radio Company, Cedar Rapids, Iowa.

Allan W. McCoy, T.M.I.A.S., Aerodynamicist, Sverdrup and Parcel, Inc., Consulting Engineers, St. Louis. Formerly, Graduate Student and Instructor in Engineering, Brown University.

Manfred Rauscher, F.I.A.S., Professor in Aeronautical Design and Structures, Federal Polytechnic Institute, Zurich, Switzerland. Formerly, Associate Professor, Massachusetts Institute of Technology.

Robert D. Spencer, M.I.A.S., Sales Manager, Safe Flight Instrument Corporation, White Plains, N.Y. Formerly, Assistant Chief, Airframe and Equipment Division, C.A.A.'s Fourth Region, Fort Worth, Tex.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Lees, Lester, Sc.M. (Aero. Engrg.), Assoc. Prof. of Aero. Engineering, Princeton University.

Transferred to Associate Fellow Grade

Becker, John V., M.S., Chief of Compressibility Research Div., N.A.C.A., Langley Air Force Base.

Freitag, Robert F., B.S.E. (Aero.), Lt. Comdr., U.S.N.; Chief of Instrumentation, Joint Long Range Proving Ground (Cocoa, Fla.).

Hedrick, Ira Grant, C.E., Chief of Structures, Engineering Dept., Grumman Aircraft Engineering Corp.

Putt, Donald L., M.S. in Ae.E., Major Gen., U.S.A.F.; Dir. of Research & Development, Hq., A.F.M.R.D. (Washington, D.C.).

Rogalski, Stanislaw, W., Dipl. of M.E., Asst. Chief Aerodynamicist, Chase Aircraft Co., Inc.

Elected to MEMBER Grade

Berggren, Willard P., Ph.D. (M.E.), Assoc. Prof. of Aero. Engineering, The Ohio State Univ.

Daley, Daniel H., S.M. in Ae.E., Asst. Prof. & Acting Head, Dept. of Mechanical Engineering, Air Force Institute of Technology.

Dawson, Lindsay G., B.Sc., Asst. Chief Supply and Services Mgr. for U.S.A., Rolls-Royce, Ltd. (England).

Dunn, Frank L., B.B.A., Col., U.S.A.F.; Deputy Chief, Intelligence Dept. (Technical), Hq., Air Materiel Command, Wright-Patterson Air Force Base.

Farmer, Edward H., M.E., Plant Engineer, Lockheed Aircraft Corp.

Klauber, Philip M., A.B., Asst. to the President, Solar Aircraft Co.

Maltby, Lewis J., B.Ae.E., Aircraft Maintenance Officer of FASRON 701, N.A.C.O.R., Naval Air Station (Dallas); Structures Development Engineer, Chance Vought Aircraft Div., United Aircraft Corp.

Norse, John, B.S. in C.E., Aero. Engineer P-3, O. & R. Div., Naval Air Station (San Diego).

Oram, John F. M., Section Leader, Structures Design Department, Bristol Aeroplane Co., Ltd. (England).

Parsons, J. Stuart, B.Sc., Chief Engineer, Technical Div., The Photographic Survey Corp., Ltd. (Ontario).

Petrou, Nicholas V., M.S., Project Engineer, Westinghouse Electric Corp.

Shreeves, Andrew, B.Sc. in N.A. & M.E., Structural Engineer, Grumman Aircraft Engineering Corp.

Sing, Edward Y., B.M.E., Liaison Engineer & Aerodynamicist, NEPA Div., Fairchild Engine & Airplane Corp.

Snow, Floyd E., Chief Engineer, Coast Paint & Chemical Co.

Stanley, Paul E., Ph.D., Assoc. Prof. of Aero. Engineering & Air Transportation, Purdue University.

Starr, G. Alan, B.S.Ae.E., Structures Engineer, Chance Vought Aircraft Div., United Aircraft Corp.

Stone, Charles T., Sc.B. in Engineering Sales Engineer, Esso Standard Oil Co.

Valdes-Tavera, Rafael, Lt. Col. & Air Attaché, Colombian Embassy (Washington, D.C.).

Vance, Edward M., Project Design Engineer, Hydro-Aire, Inc.

Transferred to MEMBER Grade

Jean, James E., B.S., Project Stress Head Engineer, Northrop Aircraft, Inc.

McTigue, George J., B. of Ae.E., Development Engineer, Aircraft Gas Turbine Div., General Electric Co. (Lynn).

Ready, Joseph A., M.S. in Engineering, Asst. Research Aerodynamicist, Wind Tunnel Dept., Cornell Aero. Lab., Inc.

Sexton, George S., M.S. in Ae.E., Aero. Engineer, Bureau of Aeronautics, Dept. of the Navy.

Ulm, Richard H., Engineering Test Pilot & Designer, Goodyear Aircraft Corp.

Elected to Associate Member Grade

Mills, C. Robert, Co-owner Operator, Philadelphia Seaplane Base.

Orndoff, Ted H., B.S. in Bus. Adm., Manufacturers Representative at Wright-Patterson Air Force Base, self-employed.

Perreault, William D., Technical Editor American Aviation Publications.

Ross, James J., Asst. to the Chairman, Mellspaugh, Ltd. (England).

Elected to Technical Member Grade

Cunningham, Herbert J., S.M. in Ae.E., Aero. Research Scientist, N.A.C.A., Langley Air Force Base.

Epps, George F., M.S. in M.E., Engineer-Designer, Douglas Aircraft Co., Inc. (El Segundo).

Manning, William, Lines Loftman, A. V. Roe Canada Ltd.

Mennell, John, Section Leader, Loft Mathematics, A. V. Roe Canada Ltd.

Roberts, Philip K., Jr., B.S., Flight Test Instrumentation Engineer, Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

Savage, John A., Engineering Materials & Equipment Inspector, Dept. of the Navy, M.C.A.S.

Sohn, Robert L., B.S. in Ae.E., Aerodynamicist, North American Aviation, Inc.

Transferred to Technical Member Grade

Alexander, W. C., B.Ae.E., Research Design Engineer, Cleveland Pneumatic Tool Co.

Bachmann, F. C., B.S., Major, U.S.A.F.; Design & Development Engineer, Overseas Base.

Balzer, Gerald H., Illustrator "B," Northrop Aircraft, Inc.

Barnett, Weaver E., A.A. in Ae.E., Engineering Technician, Ordnance Aerophysics Lab., Consolidated Vultee Aircraft Corp. (Daingerfield).

Benstein, Eli H., B.Sc.

Bischoff, Elton L., B.M.E., Graduate Student, Syracuse University.

Black, Richard E., M.S. in Ae.E., Stress Analyst, Douglas Aircraft Co., Inc. (Santa Monica).

Blakely, Sylvester F., B.S.M.E. (Aero.), Lt. & Student Pilot, U.S.A.F., Randolph Air Force Base.

Bogart, Carl W., B. of Ae.E., Engineering Trainee, Propulsion Section, The Glenn L. Martin Co.

Brull, Maurice A., B.S. (Aero.), Instructor in Aero. Engineering, University of Colorado.

Buehl, Fred W., B.E., Graduate Student in Aero. Engineering, University of Southern California.

Catchpole, E. J., B.Sc. (Eng.), Graduate Trainee, Vickers-Armstrong, Ltd.

Chapman, Howard M., Jr., B.S.Ae.E., Naval Aviation Cadet, N.A.A.S. (Whiting Field).

Cook, Arthur B., B.S. in Ae.E., Experimental Inspector, McDonnell Aircraft Corp.

Cowan, Lloyd G. H.

Dallas, Walter H., B.S., Lt., U.S.A.F.; Design & Development Officer, Projects Control, Edwards Air Force Base (Muroc).

Daniels, W. D., Engineering Draftsman "B," Aerojet Engineering Corp.

Dees, Henry Baird, B.S.

Eilert, Morgan B., Jr.

Ernst, Edward A., B. of Ae.E., Aero. Research Scientist, N.A.C.A. (Moffett Field).

Faber, Stanley, B.S. in M.E. (Aero.), Aero. Research Scientist, N.A.C.A., Langley Air Force Base.

Fischbach, Joseph W., M.A.E., Ordnance Engineer P-5, Ballistics Research Lab. (Aberdeen).

Fischer, Robert G., B.S.Ae.E.

Forbes, Robert L., Engineering Draftsman, Beech Aircraft Corp.

Forys, Joseph E., Draftsman, Northrop Aircraft, Inc.

Freeman, Carroll, B.S.Ae.E., President, ServeAero Corp.

Gee, Alvin H., Aircraft Structures Inspector, Northrop Aircraft, Inc.

Goskowski, Raymond J., A.A. in A.E.

Hall, William B., B.Ae.E., Aerodynamics Engineer, Columbia Research & Development Corp.

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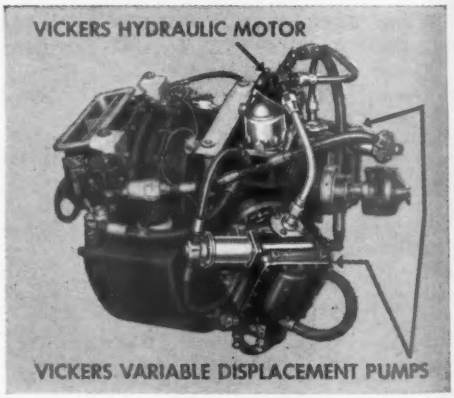

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Personnel Opportunities

This section is for the use of individual members of the Institute seeking new connections and organizations offering employment to Aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

Wanted

Design Engineers—For work on heavy-type bomber aircraft. Requires a B.S.E. and a minimum of 5 to 10 years' aircraft experience in wings, landing gear, controls, empennage, hydraulics, and body and electrical design. Please direct reply to Administrative Engineer, Boeing Airplane Company, Wichita Division, Wichita, Kan.

Research Positions—Open for physicists, mathematicians, and statisticians with the Naval Ordnance Test Station, Pasadena, Calif. Real opportunity is offered to high-caliber scientific personnel to work with top management in evaluation of weapons research and development. These are Civil Service positions GS-11 to GS-15 ($5,400 to $10,000). Reply with brief outline of education and experience to Personnel Department, Naval Ordnance Test Station, 3202 E. Foothill Blvd., Pasadena, Calif.

Preliminary Analysis and Design Engineers—Must have 3 to 10 years' aircraft experience with minimum of 2 years in aircraft or missile preliminary analysis and design. Advanced degrees and experience in supersonic design, configuration analysis, and economic evaluation are particularly desirable. **Aerodynamics Engineers**—To perform studies in supersonic aerodynamics on extensive guided-missile program. Positions open for men with training and experience in dynamic stability, performance, configuration development, aerothermodynamics, and flight testing. Salary dependent on qualifications. Address: Aerophysics & Atomic Energy Research Division, North American Aviation, Inc., 12214 Lakewood Blvd., Downey, Calif.

Research and Development—Electronics Engineers, Senior—Degree, plus 4–8 years' experience as Project Engineer in radar, design system, and circuit analysis. **Intermediate** ratings for Electronics Engineers with degree, plus 2–4 years' experience in circuit design, antenna and microwave design. **Electromechanical (Fire Control System)**—Degree with at least 4 years' experience in either servomechanisms, analogue computers, or circuitry development. Must have academic training in mathematics. **Electromechanical engineer in flight test, Senior**—Minimum of B.S. degree, but M.S. degree desired. At least 5 years' experience in instrumentation in research laboratory testing and devising new measurement systems. Will be responsible for technical integrity and further development of flight-test instrumentation. **Structures engineer, Senior**—Engineering graduates with at least 3 years' experience in aircraft structural analysis techniques sufficient to adapt and modify equations and analysis methods to meet specific structural problems. Must have good knowledge of report-writing techniques. Those with at least 1½ years' experience will be considered for intermediate openings. **Aerodynamic Engineers, Senior**—Technical graduates with at least 4 years of proved experience in aerodynamics work in either performance, stability and control, air loads or flight-test reduction. Graduates with advanced degrees with thesis in aerodynamics or thermodynamics and at least 2 years' experience in aircraft will also be considered. **Heating and Ventilating Engineer in Aerodynamics, Senior**—Degree and 5 years' experience in aircraft cabin conditioning and anti-icing systems. Knowledge of heat transfer, thermodynamics, and gas dynamics. Familiar with design and installation of cabin conditioning equipment. **Propulsion Engineer, Senior**—Degree and 5 years' experience in air-frame or power-plant development and installation. Familiar with design and operation of power-plant components. Familiar with turboprop, jet, ram-jet. Background in thermodynamics, fluid dynamics, and gas dynamics. Must be analytical and capable of good analysis report writing. Send résumé to Employment Department, The Glenn L. Martin Company, Baltimore 3, Md.

Thermodynamicist—Graduate engineer to perform design analyses in one or more phases of aircraft power-plant installations, such as duct flow, heat transfer, cabin conditioning, or fuel system analysis. Minimum 2 years' experience. Apply Engineering Personnel Manager, Northrop Aircraft, Inc., Hawthorne, Calif.

Graduate Mechanical or Chemical Engineer—For design and analytical work. To do research on rocket engine components. Experience in combustion, thermodynamics, and heat transfer essential. Additional experience in hydraulics, machine design, and metallurgy desirable. Willingness and ability to use mathematical analysis and theoretical background required. Aerojet-Engineering Corporation, P.O. Box 296, Azusa, Calif.

Graduate Mechanical or Chemical Development Test Engineer—To supervise test operations and rocket engine components. Experience in aircraft engine or allied test fields essential. Knowledge of, or experience in, instrumentation, hydraulics, and aircraft hydraulic systems desirable. Should have B.S. degree; advanced degree desirable. Must be willing to accept responsibility entailed in this type of test operation. Aerojet Engineering Corporation, P. O. Box 296, Azusa, Calif.

187. Part-Time Instructor—To teach basic aeronautical subjects in large southeastern engineering school. Ideal opportunity for graduate work in related fields. When applying send complete transcript of college credits.

186. Structural Engineer—Having a minimum of 3 to 4 years of extensive aircraft (preferably including some helicopter background) stress analysis experience, preparing stress data in accordance with Air Force, Navy, and C.A.A. specifications requirements. Those having supervisory experience in directing structural designers and draftsmen given special consideration. Only applicants having practical knowledge of formal stress-analysis procedures are asked to apply. Submission or personal data should include comprehensive descriptions of previous positions, salary, scope of assignments, and chief interest in aeronautical engineering field.

180. Professor of Aeronautical Engineering—Qualified to teach fluid mechanics, gas dynamics, thermodynamics, and specializing in jet and rocket engines. Advanced degrees required. Salary open. Location Mid-West.

The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

179. Professor of Aeronautical Engineering—To teach undergraduate aerodynamics, compressible fluids, performance, or stability courses. Some research facilities available. Advanced degrees required. Some graduate teaching. Salary open. Location Mid-West.

167. Assistant Professor—Required to teach undergraduate and graduate courses in heat transfer and vibrations beginning September. Preference given those with doctorate in either mechanical or aeronautical engineering. Location Philadelphia. Include small photograph when applying.

Available

194. Assistant Professor—Doctor's Degree in Mechanical Engineering. Seven years' teaching and research experience on undergraduate and graduate levels. Air Force Project Leader. Specialized in mathematical fluid mechanics and applied mechanics. Wants similar position with large university.

193. Aeronautical Engineer—Graduate of 2-year aeronautical engineering course with high average, October, 1949. Experience in aircraft-seat designing and building since graduation. Proficient draftsman. Familiar with all shop tools. Capable of assuming responsibility. Desires locating on East Coast. Interested in designing, particularly tool designing.

192. Engineering Executive—Widely experienced in industrial and Governmental organization and practice. Graduate engineer and commercial pilot. Work in private industry has included aircraft design, project engineer, engineering administration, engine sales and service, manufacturer's Washington representative. Military wartime assignments in responsible aviation engineering, material, and maintenance posts. Postwar supervision of research and development programs. Capable of taking full responsibility for projects or of working as member of team.

191. Aeronautical Engineer—B.S.Ae.E., Aeronautical University, 1950. Would like starting opportunity in design and research, preferably in the field of rocket and jet propulsion. Some machine-shop and aircraft sheet-metal experience. Good scholastic record. Willing to continue schooling. Age 26, location open.

190. Senior Aerodynamic Engineer—With excellent theoretical background and wide practical experience. Expert in stability and control, servomechanisms analysis, dynamic problems, air loads, and remote control. Familiar with all angles of modern aerodynamics, pilotless airplanes, etc. Desires work in research, development, or preliminary design.

188. Aerodynamicist—B.S. in Aero., B.S. in Math., M.S. in Aero. Desires responsible position with research or development organization in or near an educational institution where advanced studies in aerodynamics, mathematics, and physics could be pursued. Has extensive experience in all phases of subsonic, transonic, and supersonic wind-tunnel testing—i.e., design, operation, and data reduction. Good background in thermodynamics and propulsion. Is familiar with shop practices. One year's teaching experience on graduate level. Would consider teaching supplemented with research.

185. Aircraft Structural Engineer—Graduate Engineer with 5 years' structures experience. This includes 1 year of stress experience on both military and civil aircraft; 1 year of structural test experience while in the A.A.F. with the Air Proving Ground Command; the last 3 years as a lead structural engineer on military aircraft with five assistants doing structural design, load analysis, stress analysis, and testing. Will locate anywhere.

184. Stress Analyst—B.S. in A.E., 1947. Two years with leading manufacturer. One year of electrical and 6 months of architectural drafting experience. Three years in the U.S.A.A.F. Location open. Age 27.

183. Aeronautical Engineer—Internationally known aeronautical engineer; 25 years' experience in sales and service. Thoroughly familiar with all types of aircraft accessories and components. Responsible for many current designs of accessories. Presently contract administrator and Washington representative of large company. Desires to represent company wishing to open or maintain Los Angeles or Pacific Coast office. Excellent contacts in all aircraft companies and Government departments.

182. Aero-Mechanical Engineer—B.Aero.E., 1943; M.M.E., 1949. Extensive experience, including supervisory duties, in the field of jet power plants. One and one-half years' design experience on all major power-plant components with leading aircraft manufacturer. Two and one-half years' experience in research and development with the N.A.C.A. as P-3 Aeronautical Research Engineer on ram-jet power plants (subsonic and supersonic) and rocket launches. Position entailed design of test equipment, setting up test program testing, processing of data, analysis of data, and technical report writing. Development work included various configurations of diffusers, nozzles, and combustion chambers. One year as Junior Project Engineer with well-known turbojet engine manufacturer doing preliminary design and performance estimations. For past 2½ years, member of Faculty, Mechanical Engineering Department, Grade A Engineering School, lecturing in thermodynamics. Worked with Research Division of University during summer months on the development of advanced type power plants. Procedures for analysis required the use of schlieren photography for flow studies. Had occasion to use special instrumentation for measurement of pressure and temperature which had been adapted to rocket performance studies. Will give consideration to any position of interest and opportunity.

181. Engineer-Administrator—Twenty-three years' experience in aircraft and engine manufacturing as engineer, technical representative, and administrator. Familiar with Government policies and personnel of Government agencies and the industry. Formerly director of market research, administrator of research and development contract, BuAer project officer, executive officer manager, contract administrator, technical assistant to treasurer, and consultant.

178. Layout Draftsman—Aeronautical sheet-metal-production design. Age 35. Five years of aeronautical drafting; 1½ years of rail car design. Two years of night school, University of Maryland, drafting. Desires position as aeronautical draftsman or in sheet-metal-production design. Location open.

177. Research or Teaching—Doctor of Aeronautical Engineering. Varied experience over a period of 8 years in the fields of design and research in fixed- and rotary-wing aircraft. Teaching position preferred either on the East or the West Coast.

176. Mechanical Engineer—B. of M.E., 1950; 3 years' experience with leading aircraft instrument manufacturer as repairman of all instruments; as instructor of Allied and American military personnel and heads of instrument departments or major aircraft companies; also some research engineering. Three years' additional experience in the U.S. Army Signal Corps as a teletype, telephone, and switchboard installer-repairman; French and German interpreter; and director of European civilian labor. Part-time experience in the planning, organizing, and procurement for new courses of instruction in a technical school. Desires a position in the instrument or electronic field. Location open. Age 29.

175. Engineer—Instructor—B. Aero. E., M. Aero.E., Professional Engineer. Two years of aerodynamics in stability and control, performance, air loads, and wind tunnel. One and one-half years as research engineer with precision instrument firm on East Coast. Experience includes precision experimental instrument design and test, purchasing, and shop liaison. Now finishing second annual contract as Instructor in Aeronautical Engineering in a New England college. Would prefer Assistant Professorship in New York or New England area or responsible industrial position. Will relocate if attractive. Full knowledge of present employer.

174. Associate Professor—S.M., M.I.T. Head of aeronautical engineering option at northern college desires position of corresponding responsibility in either teaching or research. Opportunity to pursue doctorate on part-time basis desirable. Location open.

173. Engineer—Six years' experience in aircraft and aircraft control system dynamics. Specialist in devising and analyzing servo controls for pilotless aircraft. Has directed analog computer studies of autopilot designs.

172. Aircraft Stress Analyst—Mechanical Engineer—Four years' experience as aircraft stress analyst. Graduate of Spartan College, Tulsa, Okla., and The University of Oklahoma, Norman, Okla., with degrees of A.A., A.E. and B.S., M.E. (Aero option). Ability to maintain authoritative and friendly relationships with draftsmen, design groups, liaison, shop, etc. Prefers to do stress and/or structural design work in Missouri, Kansas, or Illinois area.

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171. **Engineer**—Eleven years' engineering and 5 years' sales experience as factory representative; management and some production experience; graduate University of Michigan and Alexander Hamilton Institute of Business Administration. Wishes to apply experience in the production department or to assist in coordinating production, sales, and engineering departments. Locality and salary open. A detailed outline of experience will be sent on request.

170. **Aeronautical Engineer**—Nine years' experience in airplane manufacture. Three years' experience covering shop liaison, design of aircraft equipment, and supervision of preparation of technical publications. In airlines, 4½ years of service and flight-test engineering, preparation of maintenance and operating manuals, and supervision of design and installation of airplane interiors and furnishings. One and one-half years' training as naval aviator. Lieutenant, Air Engineer Officer, Naval Reserve. Has completed to date one-half of, and continuing with courses leading to, B.Sc. in Commerce. Interested in sales and service position with manufacturer or in combined administrative-technical position with air line. Location open.

169. **Sales Executive and Economist**—Familiar with operating and market analysis; extensive management and sales experience in this country and abroad; widespread Government and industry contacts; 10 years in Washington. Technical background, two degrees, pilot, and well-known writer. Prefers East Coast location, but will go anywhere.

168. **Teacher**—Desires position teaching aeronautical engineering or engineering mechanics at recognized college or university. B.Ae.E. degree, Magna Cum Laude. M.S. in Ae.E. Three years of progressively responsible industrial experience, including stress analysis and design of tubular and stressed-skin structures and of the mechanical elements of civilian and military aircraft with emphasis in rotary-wing field. Over 4 years of college teaching experience as instructor and assistant professor. Qualified to teach graduate courses in theory of elasticity and elastic stability, experimental stress analysis, rotary-wing aerodynamics, etc., as well as undergraduate curriculum in aerodynamics, aircraft structures, and airplane design. In reply, please discuss rank available and salary schedule.

166. **Aeronautical Engineer**—Research Aerodynamicist with 7 years' practice. Doctor's degree. Age 28. Author of several papers. Has worked on propulsion and supersonic problems. Presently working on original analytical design procedures for compressors and turbines. Experienced report writer. Desires supervisory research position or consulting work. Also interested in the hydrodynamic propulsion problems of water-craft.

165. **Aeronautical Engineer**—Summer position. M.Ae.E., New York University in June, 1950. Beginning doctoral work in September. One year's industrial experience in design and stress analysis. Age 26. Prefers stress analysis or teaching but will consider any offer in New York vicinity.

164. **Air-Line Operations Engineering—Airport Management**—Training at Denver University, Parks College, and Spartan School of Aeronautics in Operations and meteorology and technical writing. Four years with A.A.F. Intelligence dealing with restricted and confidential manuals in maintenance and Air Transport Command Flight Operations. Familiar with air-line operations problems at large eastern airports. Also trained in A.A.F. 1st Helicopter Training Unit. Has postwar training in latest sales and airport and aircraft insurance underwriting procedures. Prewar aeronautical engineering training at V.P.I. Extension and at University of Alabama. Desires position with large fixed-base or airport management assistant.

Members Elected

(*Continued from page 85*)

Haskins, Roy G., B.S. in Ae.E., Student Officer, 3510 Basic Pilot Training Group, U.S.A.F., Randolph Air Force Base.

Hays, Perry O.

Hurt, Doris M., B.S.E., Traffic and Sales Representative, Trans-Canada Air Lines.

Husen, Carl F., Jr., B. of Ae.E., Graduate Student, Rensselaer Polytechnic Institute.

Irwin, Harry Joseph, Jr., B.S. in Ae.E.

Kelly, J. P., A.A. in Ae.E.

Klindworth, David G., B.S. in Ae.E., Development Engineer, Goodyear Aircraft Corp.

Kuczwara, John W., B.S.Ae.E.

Ladd, Garth C., B.Ae.E., Graduate Student & Asst., Aero. Dept., Rensselaer Polytechnic Institute.

Laidlaw, William Robert, B.A.Sc., Postgraduate Student, Massachusetts Institute of Technology.

Lenz, Kenneth E.

Lutwak, Sol, B. of Ae.E., Asst. Stress Analyst, McCulloch Motors Corp.

MacLellan, A. D., B.S.E. (Ae.E.).

Mattice, Hubert C., B.A.E., Asst. Instructor, Rensselaer Polytechnic Institute.

McDonnell, Harold E., B.A.E., Project Test Engineer, Naval Air Test Center, Flight Test (Patuxent River).

Mellinger, Harry K., B.S., Aero. Engineer, Design Modification, Hq., U.S.A.F., Air Materiel Center, Wright-Patterson Air Force Base.

Moore, Douglas A., Engineering Draftsman, Radar Antenna Mech. Design Group, Hughes Aircraft Co.

Narnst, Donald M., Draftsman—II, General Electric Co. (Richland, Wash.).

Newcome, George C., Jr., B.S. in A.E.

Olson, Bernard A., B. of Ae.E., Jr. Engineer, Boeing Airplane Co. (Seattle).

Phillips, Houston A., Flight and Service Mechanic, Consolidated Vultee Aircraft Corp. (Ft. Worth).

Piper, James E., B. Aero. E., Engineering Asst. "A," Consolidated Vultee Aircraft Corp. (San Diego).

Proffitt, James V., B.S., 2nd Lt., U.S.A.F., Goodfellow Air Force Base.

Rucker, Robert R., Technical Illustrator, North American Aviation, Inc.

Scherer, Jack P., B.S. in Ae.E., Engineering Draftsman, Jentzen-Miller Co.

Septynski, Joseph F., B.S.Ae.E.

Sivak, Michael J., B.Ae.E.

Smith, Dale H., Engineering Draftsman, North American Aviation, Inc.

Smith, Robert F., B.S. in A.E.

Spear, Shelton G., B.S., 1st Lt., U.S.A.F.; Student Officer, Air Force Institute of Technology.

Swanstrom, Carl W., B.S.Ae.E.

Takatsuka, Bobby T., B.S.E. (Aero.).

Teague, Emmett C., B.S.Ae.E., Engineering Draftsman, Douglas Aircraft Co., Inc. (El Segundo).

Tompkins, Henry H., B.Ae.E., Graduate Student, Rensselaer Polytechnic Institute.

Venere, Lawrence A., B.S. in Ae.E.

Wan, Koon-Sang, M.S., Graduate Student, Polytechnic Institute of Brooklyn.

Waters, Kenneth T., B. of Ae.E., Jr. Aero. Engineer, Flight Test, Piasecki Helicopter Corp.

Wegner, Earl T., B.S.E. (Aero.).

Wells, Thomas F., B.Ae.E.

Wetzel, Albert J., B.E., Major, U.S.A.F.; Student, The Johns Hopkins University.

Wise, William E.

Wu, Theodore Y. J., M.S., Graduate Student and Research Asst., Aero. Dept., California Institute of Technology.

Young, Edward K., Draftsman, Hughes Aircraft Co.

Young, Karl.

Zeigler, Robert O.

Zosky, Edward W., Engineering Draftsman "B," North American Aviation, Inc.

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★ *Specifications and further information on the aircraft products of these companies will be found in the*

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Most powerful airplane of its size and type ever developed, the new Navy A2D-*Skyshark* is designed to fill the military need for all 'round tactical ground support and sea-air attack.

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Thus the A2D becomes the proud successor to the versatile Douglas AD-*Skyraider* series of attack aircraft.

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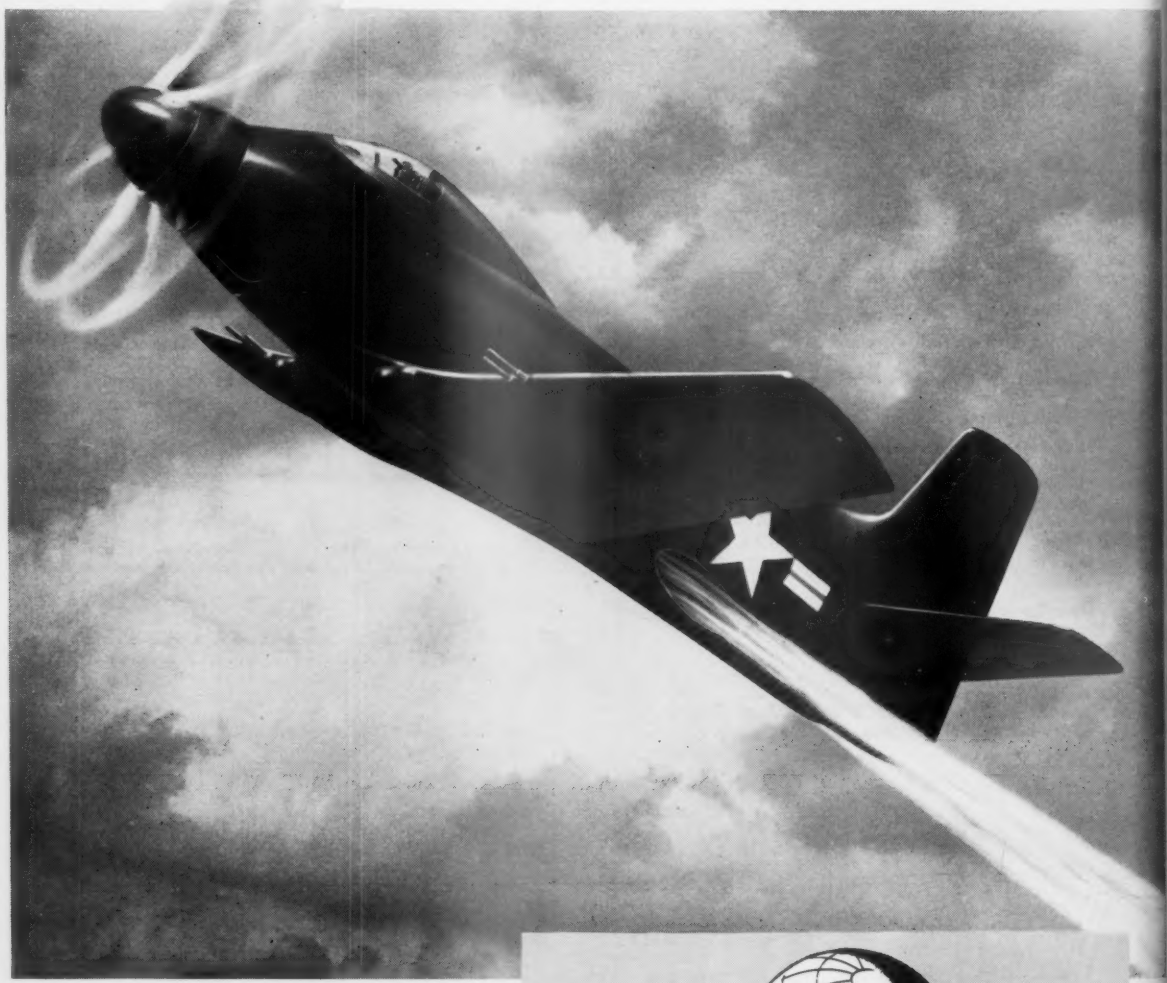

DEPEND ON DOUGLAS

30TH ANNIVERSARY YEAR

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